

10th European Conference
and Technology Exhibition

Biomass for Energy and Industry

Proceedings
of the International
Conference
Würzburg, Germany
8-11 June 1998

UNIVERSITÄTSBIBLIOTHEK
HANNOVER
TECHNISCHE
INFORMATIONSBIBLIOTHEK

Edited by
H. Kopetz
T. Weber
W. Palz
P. Chartier
G. L. Ferrero



C.A.R.M.E.N.

Table of Contents

Page	
	Opening Addresses
42	<i>Ernst Hinsken</i> <i>Parliamentary State Secretary to the Federal Minister of Food, Agriculture and Forestry</i>
46	<i>Gerd Sonnleitner</i> <i>President of the German Farmers' Association, Germany</i>
	Fundamental Global and European Aspects
48	<i>Catastrophes and Climate Change: Costs to and Countermeasures of the Insurance Industry</i> <i>Gerhard Berz, Munich Reinsurance Company, Germany</i>
	Session OR1: Worldwide Strategies for Biomass
52	<i>The Role of Bioenergy in Developing Countries</i> <i>D.O. Hall & F. Rosillo-Calle, King's College London, United Kingdom</i>
56	<i>Indian Experience of Biomass Power Plants Based on IISC - DASAG Gasifiers and Strategies for their Large Scale Commercialisation</i> <i>H. Sharan, DASAG, Switzerland</i>
59	<i>Bioenergy in North America: An Overview of Liquid Biofuels, Electricity and Heat</i> <i>R. Overend, National Renewable Energy Laboratory, USA</i> <i>R. Costello, U.S. Department of Energy, USA</i>
62	<i>Perspectives of Biomass Energy in the European Union - How a 200% Increase can be Attained</i> <i>P. Chartier & C. de Silguy, ADEME, France</i> <i>L. Battias & S. Defaye, Comité de Liaison des Energies Renouvelables, France</i>
	Session OR2: Biomass Policies in Europe
67	<i>The Importance of Small Biomass Stoves for Future Energy Supply from the Point of View of the Builders of Tiled Stoves</i> <i>P. Kröplin, Fachverband Sanitär-, Heizungs- und Klimatechnik Bayern, Germany</i>
70	<i>Acceleration of Bioenergy Development in the Netherlands</i> <i>K. Kwant & G.J.J. Smakman, NOVEM, The Netherlands</i>
73	<i>Job Creation in SMEs by Regional Programmes to Boost Wood-Based Individual Heating Systems</i> <i>G. Dell & C. Egger, OÖ Energiesparverband, Austria</i>
	Session OR3: Biomass Derived Industrial Products and Materials
77	<i>Recent Developments in the Chemical-Technical Sector of Agricultural Resources in Germany</i> <i>A. Schütte, Fachagentur Nachwachsende Rohstoffe, Germany</i>
79	<i>Bio-Composites - New Construction Materials Derived from Biomass</i> <i>J. Nickel, U. Riedel & A.S. Herrmann, DLR, Germany</i>
86	<i>Natural Apple Peel Wax, a Renewable Raw Material as a New Cosmetic Ingredient</i> <i>T.C. Kripp, Wella, Germany</i>
90	<i>High-performing Lubricants Based on Renewable Resources</i> <i>J. Legrand & K. Dürr, FINA Research, Belgium</i>
93	<i>Progress in the Synthesis of Lignocellulosic Thermoplastics</i> <i>C. Vaca-Garcia & M.E. Borredon, ENSCT, France</i>
97	<i>Application of Starch Based Anionic Flocculant in the Water Treatment</i> <i>J. Dencs & G. Marton, University of Veszprém, Hungary</i>
101	<i>Life Cycle Assessment 'Life Cycle Net Hemp Products'</i> <i>A. Patyk, IFEU, Germany</i>
105	<i>Starch Based Materials: Properties, Applications and Future Perspectives</i> <i>C. Bastioli & L. Marini, Novamont, Italy</i>
108	<i>Creating the Framework for the Widespread Use of Biodegradable Polymers</i> <i>J. Schroeter, Fachhochschule Rosenheim, Germany</i>

Page

Session OR4: Biofuel Production and Utilisation in the Transporting Market

- 112 Development of Biodiesel Activity in France
F. Staat, Diester Industrie, France
- 116 First Total Ecological Assessment of RME (Biodiesel) versus Diesel Oil
G.A. Reinhardt, IFEU-Institut, Germany
- 120 Geno- and Cytotoxic Effects of Biodiesel Exhausts (Rape Seed and Soybean Oil Methyl esters)
J. Bünger, A. Weigel & E. Hallier, Georg-August-Universität, Germany
J. Krahl, Fachhochschule Coburg, Germany
K. Prieger & A. Munack, FAL Braunschweig, Germany
- 124 Production of Vegetable Oils in Decentral Plants and Aspects of Quality Management - Investigations on Plants in Practice to Optimise the Process
B. Widmann, Technical University of Munich, Germany
- 128 Successful Marketing for Biodiesel in Germany
K. Groenen, Union for Promoting Oilseeds and Protein Plants, Germany
- 131 Process Chain Analysis for the Production of Methanol from Wood
G. Saller, G. Funk & W. Krumm, University of Siegen, Germany
- 134 Optimizing Peracetic Acid Pretreatment Conditions for Improved Simultaneous Saccharification and Co-Fermentation (SSCF) of Woody Biomass to Ethanol
L.C. Teixeira, J.C. Linden & H.A. Schroeder, Colorado State University, USA
- 138 Production of Acetone, Butanol and Ethanol (ABE) from Agricultural Residues or Domestic Organic Waste (DOW) and Long-Term Fermentation on Glucose
P.A.M. Claassen, M.A.W. Budde, R.M. Buitelaar & G.B.N. Tan, ATO-DLO, The Netherlands

Session OR5: Biogas

- 142 Carbon Balances for Biogas Production and Composting
K.B. Salomonsen, Technical University of Denmark, Denmark
J. Magid, The Royal Veterinary and Agricultural University, Denmark
- 145 Methods for Increasing the Biogas Potential from the Recalcitrant Organic Matter Contained in Manure
B.K. Ahring & I. Angelidaki, Technical University of Denmark, Denmark
- 149 Experimental Plant for the Production of Electric Power through the Use of Purified Biogas from a Landfill of Municipal Solid Waste (M.S.W.)
A. Cioli, P. Daddi & F. Mori, PUBLISER, Italy
- 153 Biogas Technology: Prospects and Potential as an Alternative Energy Source in the Center Himalayan Region, India
R. Prasad & A. Sharma, TERI, India
B.K. Bhatt, Ministry of Non-Conventional Energy Sources, India
- 156 Energy-Related Processing of Organic Wastes in Agricultural Biogas Plants in Combination with the Effective Use of Fertilizers
U. Behmel & R. Meyer-Pittroff, Technical University of Munich, Germany
- 160 Cofermentation of Organic Wastes and Agricultural Manures
T. Amon, J. Boxberger, J. Lindworsky & M. Scheibler, BOKU Landtechnik, Austria
- 163 Agricultural Crops for Biogas Production on Anaerobic Digestion Plants
P. Pouech, SOLAGRO, France
H. Fruteau, Steimuller Valorga, France
H. Bewa, ADEME, France
- 166 Wirtschaftliche Auswertung von Biogasanlagen in Bayern
J. Sedlmeier, Landwirtschaftliche Lehranstalten Triesdorf, Germany

Session OR6: Insulating Materials from Renewable Resources

- 169 Effectiveness of Insulation Materials from Renewable Resources such as Sheep's Wool, Flax and Wood-Wool Slabs
E. Podesser, Deutsche Heraklith, Germany
- 171 Practical Experiences with Alternative Insulating Materials
B. Schwarz, Fachhochschule Rosenheim, Germany
- 173 Thermal Insulation Based on Loose Wood Chips
K. Vogel, G. Wegener & F. Tröger, University of Munich, Germany

Page

- 176 Arable Crop Materials for Insulation in Buildings
D.P.L. Murphy & H. Behring, Federal Agricultural Research Centre, Germany
- 180 LCAs of Insulating Materials - a Comparison
F. Werner & K. Richter, EMPA, Switzerland
- Session OR7: Biomass Energy Crops and Residues**
- 184 Influences on the Quality of Solid Biofuels - Causes for Variations and Measures for Improvement
H. Hartmann, Technical University of Munich, Germany
- 188 Fuel Mix Supply Reliability for Biomass-Fired Heat and Power Plants
R.E.H. Sims, University of Massey, New Zealand
D. Culshaw, ETSU, United Kingdom
- 192 Utilization of Ashes from the Combustion of Hay, Miscanthus, Hemp, Straw and Wood as Fertilizer
P. Hasler, Verenum Research, Switzerland
T. Candinas, Institute of Environmental Protection and Agriculture, Switzerland
T. Nussbaumer, Verenum Research/Swiss Federal Institute of Technology, Switzerland
- 196 Densification, Relaxation and Burning Characteristics of Rice Straw and Saw Dust Briquettes
H.M. Rajabu, G.R. John & J.R. Masuha, University of Dar es Salaam, Tanzania
B.M. Jenkins, University of California, USA
- 200 Commercial Harvest of Willow Wood Chips in Sweden
S. Larsson, Svalöf Weibull, Sweden
G. Melin, Agrobränsle, Sweden
H. Rosenqvist, SIMS, Sweden
- 204 The Timing and Stubble Height of Delayed Harvest of Reed Canary Grass Grown for Energy and Fibre Use in Finland
K. Pahkala, Agricultural Research Centre, Finland
- 207 Management Guide for the Production of Switchgrass for Biomass Fuel in Southern Iowa
A. Teel, Iowa State University, USA
- 209 Biomass and Sugar Yields of Sweet Sorghum in Greece
A. Chatziathanssiou, M. Christou, E. Alexopoulou & C. Zafiris, CRES, Greece
- Session OR8: Combustion of Biomass**
- 213 Combustion of Biomass - An Overview
M. Madsen, Elkraft Power Company, Denmark
- 216 Further Development of Proven Plant Technology for Biomass Fuels Outlined Exemplarily by Plants in Operation
K. Lubber, ESP-GEKO, Germany
- 220 Biomass Furnaces for Central Heating Systems
L. Lasselsberger, H. Baumgartner & M. Wörgetter, BLT, Austria
- 224 Possibilities and Evaluation of Straw Pretreatment
N.O. Knudsen, I/S Nordjyllandsvaerket, Denmark
P.A. Jensen & K. Dam-Johansen, Technical University of Denmark, Denmark
B. Sander, ELSAMPROJEKT, Denmark
- 229 Evaluation of Biomass Combustion in a Cyclone Slag Tap Furnace
T. Heinzl, J. Baum, J. Wohlfahrt, H. Spliethoff & K.R.G. Hein, University of Stuttgart, Germany
- 235 Fractionated Heavy Metal Separation in Biomass Combustion Plants - Possibilities, Technology, Experiences and New Approaches
F. Biedermann & I. Obernberger, Technical University of Graz, Austria
- 241 Thermodynamic and Experimental Investigations on the Possibilities of Heavy Metal Recovery from Contaminated Biomass Ashes by Thermal Treatment
J. Dahl & I. Obernberger, Technical University of Graz, Austria
- 245 Optimization of the Fabric Filter Operation for the Removal of HCL and PCDD/F from Urban Waste Wood Combustion Plants
T. Nussbaumer, Verenum Research/Swiss Federal Institute of Technology, Switzerland
P. Hasler, Verenum Research, Switzerland

Page

- 249 Formations of Dioxins and PAH in Domestic Wood Furnaces - Contamination of Fluegas, Ash and Chimney Soot
T. Launhardt, Technical University of Munich, Germany
- 253 Technical Large-Scale Test for Biomass Co-Combustion in a Lignite-Fired Power Plant
R. Dietl & W. Schmidt, Bayernwerk, Germany
- 259 Combined Heat and Power from Wood Biomass - Evaluation of Performance and Economics
C. Ekström, A. Cavani, L. Liinanki & M. Westermark, Vattenfall Utveckling, Sweden
- Session OR9: Advanced Thermochemical Conversion Processes and Novel Applications**
- 264 Biomass and Waste - Thermochemical Conversion Activities in EC Programmes
K. Maniatis, M. Papadoyannakis & A. Segerborg-Fick, European Commission, Brussels
- 268 The Status of Fast Pyrolysis of Biomass in Europe
A.V. Bridgwater, Aston University, United Kingdom
- 272 Evaluation of Gas Cleaning Technologies for Biomass Gasification
P. Hasler, Verenum Research, Switzerland
R. Buehler, Umwelt & Energie, Switzerland
T. Nussbaumer, Verenum Research/Swiss Federal Institute of Technology, Switzerland
- 276 Full-Scale Electricity Production Using Pyrolysis Gas in Denmark
R.M. Hummelshøj, COWI, Denmark
- 280 Two Years Experience with the FICFB-Gasification Process
E. Fercher, Austrian Energy, Austria
H. Hofbauer, T. Fleck, R. Rauch & G. Veronik, University of Technology Vienna, Austria
- 284 Hydrogen from Biomass
Y. Chughtai, H & C Engineering, Germany
H. Kubiak, DMT, Germany
- 287 A Small-Scale Biomass Fuelled Gas Turbine Power Plant
J.D. Craig, Cratech, USA
C.R. Purvis, U.S. Environmental Protection Agency, USA
- 291 Experiences from the Biomass Fuelled IGCC Plant at Värnamo
K. Ståhl & M. Neergaard, Sydkraft, Sweden
- Session OR10: Implementation Issues**
- 295 Implementation Issues - An Overview
E. Ortmaier, Technical University of Munich, Germany
W. Ortinger, Bavarian State Ministry of Food, Agriculture and Forestry, Germany
- 299 Life Cycle Analysis of District Heating with Biomass
H. Stockinger & I. Obernberger, TU Graz, Austria
- 303 Biomass Cogeneration Plant Schongau-Altenstadt - The Way from Idea to Realisation
T. Steer, hs Beratung, Germany
S. Schuster, BHKW Schongau-Altenstadt, Germany
D. Hein, Technical University of Munich, Germany
- 307 Administrative Policy Instruments Influencing the Wood Fuel Market: Legislation on Natural Resources and Wood Fibre Use
B. Hillring, University of Agricultural Sciences, Sweden
- 310 National and Pan-European Good Practice Guidelines for the Development of Sustainable Biomass Energy Schemes in Europe
C. Foster, ETSU, United Kingdom
- 314 Strategies for the Energetic Use of Biomass in Bavaria - Illustrated by Projects in Operation, under Construction and Development
E. Ortmaier & D. Hein, Technical University of Munich, Germany
- 319 Bioenergy in the European Low-Temperature Heat Market
J. Schmidl, Austrian Biomass Association, Austria
- 324 The Bioenergy Programme of the International Energy Agency
O. Gíslérud, IEA, Norway
- 327 The Lasting Importance of Biomass for the Society
F. Moser, Technical University Graz, Austria

Page

Session P1: Worldwide Strategies for Biomass

- 330 P1.1 Optimisation of Western European Bioenergy and Biomaterial Strategies for Greenhouse Gas Emission Reduction in the 21st Century
D.J. Gielen & J. van Doorn, ECN, The Netherlands
- 333 P1.2 Necessity and Changes of Energy from Biomass and its Hindrance for Succeed
A. Strehler, Technical University of Munich, Germany
- 336 P1.4 European Biomass Associations
C. Baldelli & J. L. Jossart, European Biomass Association, Belgium
- 337 P1.7 Production and Consumption Potentials for Bioenergy in Finland
S. Helynen, VTT Energy, Finland
- 341 P1.9 Electricity from Sugarcane in Brazil
A. Bauen & F. Rosillo-Calle, King's College London, United Kingdom
L. Cortez & S. Bajay, State University of Campinas, Brazil
- 345 P1.11 Biomass Energy Crops of Semi Arid Regions of India and their Energy Potentials
A. Kumar, University of Rajasthan, India
- 349 P1.12 Bioenergy Potential of Hungary
L.B. Szendrodi & L.F. Zsuffa, University of Sopron, Hungary
- 358 P1.14 Biotrade: International Trade in Renewable Energy from Biomass
A. Faaij & A. Agterberg, Utrecht University, The Netherlands
- 362 P1.15 Potential Sources of Biomass and Possibilities of their Utilization for Energy in Slovakia
J. Ilavský & M. Oravec, Forest Research Institute, Slovakia
- 365 P1.16 Future Contributions from Biomass to New Zealand's Primary Energy Supply
R.E.H. Sims, Massey University, New Zealand
- 369 P1.17 Fuelchip Harvesting in Italian Forestry
R. Spinelli & R. Spinelli, CNR, Italy
- 373 P1.18 Thermochemical Conversion Research & Development Activities in Canada
E.N. Hogan, Natural Resources Canada, Canada
- 377 P1.19 Stop Burning Biomass!
C. J. de Gruiter, De Brienenoord Factor, The Netherlands

Session P2: Biomass Derived Industrial Products and Materials

- 380 P2.1 Total Utilization of Cork
L. Gil, INETI, Portugal
- 382 P2.2 Flax - A New Product for the Manufacturing in the Fleece-Industry
E. Langer, C.A.R.M.E.N., Germany
- 386 P2.3 Suberin-Based Polyurethanes: Synthesis, Characterization and Kinetics of their Formation
N. Cordeiro, University of Madeira, Portugal
N. Belgacem & A. Gandini, Ecole Française de Papeterie, France
C. Pascoal Neto, University of Aveiro, Portugal
- 390 P2.4 New Ceramic Materials derived from Biogenic Raw Materials
S. Kleber, Fraunhofer Institut, Germany
- 393 P2.5 Paperfoam - made by recycled paper and starch
F. Priehs, PSP Papierschaum, Germany
- 395 P2.6 Cultivating Cat's Tail (*Typha latifolia*, L.) - a Crop with High Ecological and Economic Potential
W. Münzer, Bayerische Landesanstalt für Bodenkultur und Pflanzenbau, Germany
- 399 P2.7 Surfactant Production in Germany: What is the Potential for Curbing CO₂ Emissions?
M. Patel, Fraunhofer ISI, Germany
A. Theiß, G. Funk & W. Krumm, University of Siegen, Germany
- 403 P2.9 Biological Synthetics Made from Agricultural Waste Products
S. Meininger & Bettina Reichl, Verpackungszentrum Graz, Austria
G. Braunegg, University of Technology, Austria

Page	
407	P2.11 Lubricants Based on Renewable Resources: A Promising Value Chain P. de Caro & A. Gaset, ENSCT, France E. Poitrat & J.-P. Gaouyer, ADEME, France S. Claude, ONIDOL, France
411	P2.12 Biodegradability and Ecotoxicity of Hydraulic Fluids Based on Rapeseed Oil Used in Agricultural Machinery <i>E. Remmele & B. Widmann, Technical University of Munich, Germany</i>
415	P2.13 Influence of Extraction Conditions on Yields and Characteristics of Pine Bark Extracts <i>G. Vázquez, G. Antorrena, J. González, S. Freire & M. López, University of Santiago de Compostela, Spain</i>
418	P2.14 Removal of Cd ²⁺ by Chemically Pretreated Pinus Pinaster Bark <i>G. Vázquez, G. Antorrena, J. González & M. López, University of Santiago de Compostela, Spain</i>
421	P2.15 Effect of Acetosolv Pulping Conditions on Reactivity of Pine Lignins with Formaldehyde <i>G. Vázquez, G. Antorrena, J. González, S. Freire & C. Rodríguez, University of Santiago de Compostela, Spain</i>
425	P2.17 Innovative Products from Steam-Exploded Residual Biomasses <i>M. Demichele, G. Cardinale, F. Nanna, F. Zimbardi & D. Viggiano, ENEA, Italy</i>
429	P2.18 Technical Suitability of Hydraulic Oils Based on Rapeseed Oil - Results of a Six-Year-Test in the Field <i>B. A. Widmann, Technical University of Munich, Germany</i>
431	P2.19 Potato Starch - New Qualities for Recent Applications <i>N.U. Haase & M.G. Lindhauer, Institute for Cereal, Potato and Starch Technology, Germany</i>
435	P2.21 Properties of Binderless Panels from Thermomechanical Aqueous Vapor Exploded Residual Softwood <i>M.N. Anglès, D. Montané & J. Salvadó, Universitat Rovira i Virgili, Spain</i>
439	P2.22 Characterization of Cellulose Pulp from Poplar via Fast Soda/Anthraquinone Cooking <i>J. Reguant, M. Neus Anglès, D. Montané, J. Salvadó & X. Farriol, Universitat Rovira i Virgili, Spain</i>
443	P2.23 Bleachable Pulps by Soda-Anthraquinone Cooking of Miscanthus Sinensis <i>M. Bao, University of Santiago, Spain</i> <i>A. Vega, Universidade da Coruña, Spain</i> <i>J. Reguant & X. Farriol, Universitat Rovira i Virgili, Tarragona, Spain</i>
446	P2.24 Thermophilic Fermentative Production of Lactic Acid from C ₅ -sugars <i>H. Danner, L. Madzingaidzo, A. Hartl & R. Braun, Institute for Agrobiotechnology, Austria</i>
450	P2.25 Extraction of Lactic Acid from Silage <i>L. Madzingaidzo, H. Danner, M. Gartner & R. Braun, Institute for Agrobiotechnology, Austria</i>
454	P2.26 Processing and Characterization of Biodegradable Products Based on Starch <i>U. Funke & M.G. Lindhauer, Institute for Cereal, Potato and Starch Technology, Germany</i>
458	P2.28 Olive Oil Production: Use of Pumace Oil in the Two-Phases Technology <i>M. Bao, M.I. Crespo & M. Domínguez, University of Santiago de Compostela, Spain</i>
460	P2.30 Some Properties of Fructose Biopolymer Levan Produced by Zymomonas Mobilis <i>I. Vina, M. Bekers, A. Karsakevich, R. Linde, S. Gonta & M. Toma, University of Latvia, Latvia</i>
464	P2.31 Ethanol and Fructose from Sugar Beets <i>R. Linde, M. Bekers, I. Vina, H. Kaminska, D. Upite & R. Scherbaka, University of Latvia, Latvia</i>
468	P2.32 Comparison of 4 Annual Fibre Crops (Hemp, Kenaf, Sorghum and Maize) in Different Environments of Northern Italy <i>S. Amaducci & G. Venturi, Università degli Studi di Bologna, Italy</i> <i>R. Benati, Università di Milano, Italy</i>
472	P2.33 Effect of Medium Components on β-Glucosidase Production from Aspergillus Niger <i>A. Brumbauer, M. Bollók, I. Füleki, K. Réczey & S. Kemény, Technical University of Budapest, Hungary</i>
475	P2.34 Properties of Non-Regenerable Bio-Adsorbent (NRBA) for Waste Water Treatment Associated with Energy Recovery <i>C. Porquet & G. Antonini, Université de Technologie de Compiègne, France</i> <i>M. Boizi & P. Girard, CIRAD-Forêt, France</i> <i>J.P. Bonhoure, Institut Supérieur Agricole de Beauvais, France</i>
479	P2.35 Hemp-Cultivation in Baden-Württemberg - Inquiry among the Farmers <i>M. Konermann & R. Vetter, Institut für umweltgerechte Landbewirtschaftung, Germany</i>

Page		
481	P2.36	Utilization of Fibrous Wastes from the Food Industry for Biological Building Materials and Insulants as well as Moulded Parts <i>G. Höhn, R. Meyer-Pittroff & W. Ruß, Technical University of Munich, Germany</i>
484	P2.37	Identification of Degradation Products from Wheat Straw in Relation to Pretreatment Conditions <i>H.B. Klinke, A.S. Schmidt & A.B. Thomsen, Risø National Laboratory, Denmark</i>
488	P2.39	Properties of Wheat Straw and Beechwood Fibre Fraction Prepared by Wet Oxidation and Enzyme Treatment <i>A.S. Schmidt, S. Hvilsted & A.B. Thomsen, Risø National Laboratory, Denmark</i> <i>J.M. Lawther, The Royal Veterinary and Agricultural University of Denmark, Denmark</i>
492	P2.40	Downstream Processing of Acetoin and 2,3-Butanediol Produced by Microbial Fermentation <i>K.G. Gupta, P. Sharma & A. Sharma, Panjab University, India</i>
496	P2.41	Concerted Action 'Chemical-Technical Utilisation of Vegetable Oils (CTVO-nett)' <i>B. Kerckow, Fachagentur Nachwachsende Rohstoffe, Germany</i>
498	P2.42	A New, Fluorescence Based, Multivariate Chemometrics Approach for the Characterization of Lignocellulosics <i>E. Koukios & E. Billa, National Technical University of Athens, Greece</i>
502	P2.43	Biodegradable Bags for Organic Waste in Switzerland - Study about the Qualities of Bags in Laboratory, in Private and Professional Compostation, in the Waste Collection as well as Ecological Evaluation of Different Collecting Systems <i>R. Estermann, U. Gallí, K. Hochuli, J.P. Kaiser & B. Schwarzwälder, Switzerland</i>
506	P2.45	Activated Carbon from <i>Pinus Caribaea</i> and <i>Tectona Grandis</i> <i>A. Padilla & B. Gamboa, Universidad de Los Andes, Venezuela</i> <i>C. Scott, Universidad Central de Venezuela, Venezuela</i> <i>R. Sánchez, Fundación para Estudios Sociales, Venezuela</i>
509	P2.48	Fasern und Verbundwerkstoffe aus Hanfsilage <i>K. Scheffer, H.B. von Buttlar & R. Einsiedel, Universität -Gesamthochschule Kassel, Germany</i>
511	P2.49	Simultaneous Saccarification and Extractive Fermentation of Lignocellulosic Materials into Lactic Acid in a Two-Zone Fermenter-Extractor System <i>P.V. Iyer & Y.Y. Lee, Auburn University, USA</i>
516	P2.50	Fibre Nettle (<i>Urtica Dioica</i> L.) as an Industrial Fibre Crop for Composites (PMC's)? <i>J. Dreyer & G. Dreyling, University of Hamburg, Germany</i>
519	P2.52	Evaluation of Oxidized Acetosolv Lignins as Chelating Agents <i>A.R. Gonçalves, M.A. Soto Oviedo, A. R. Cotrim, F. T. Silva & A. Ferraz, FAENQUIL, Brazil</i>
522	P2.53	Multiple Uses of Erythrina - Nitrogen Fixing Tree Legume <i>M.N.V. Prasad, University of Hyderabad, India</i>
	Session P3:	Biofuel Production and Utilisation in the Transporting Market
525	P3.2	Diesel Fuel Containing 20 % of Rapeseed Oil Methyl Ester (RME) - Trials on the Engine Tests Beds <i>Z. Lukasik, Institute of Petroleum Processing, Poland</i>
528	P3.3	Cetane Numbers, Cetane Improvement and Precombustion of Fatty Compounds in Biodiesel <i>G. Knothe, U.S. Department of Agriculture, USA</i>
533	P3.4	Economically Optimal Production and Allocation of Biofuels for Transport in the Netherlands <i>P. Lako, D.J. Gielen, L. Dinkelbach & R. van Ree, ECN, The Netherlands</i>
537	P3.5	Continuous Fermentation and Stripping <i>F. Taylor, A.J. McAloon & J.C. Craig Jr., U.S. Department of Agriculture, USA</i>
540	P3.6	Production of Fuel Ethanol from Lignocellulosic Feedstocks in Canada <i>W.H. Cruickshank & C. Barraud, Natural Resources Canada, Canada</i>
544	P3.7	Environmental Impacts and System Analysis of Biofuels <i>U. Wagner, B. Geiger & T. Dreier, Technical University of Munich, Germany</i>
549	P3.9	Biodiesel and Bioethanol in Czech Republic and Slovak Republic - Present State, Production Prospectives and Utilization <i>Z. Pokorný, VUZT Research Institute of Agricultural Engineering, Praha, Czech Republic</i> <i>J. Cvengroš, Slovakian Technical University, Slovakia</i>

- Page
- 552 P3.10 Membrane Separation of Ethanol/Water Mixtures by Film Vaporization to be Coupled with Fermentation Unit
A. Tosun-Bayraktar, A. Isambert, D. Depeyre & G. Durand, Ecole Centrale Paris, Chatenay-Malabry, France
- 556 P3.11 Improving the Low-Temperature Operability of Biodiesel
R.O. Dunn, U.S. Department of Agriculture, USA
- 560 P3.12 Ethanol Bioproduction from Steam Exploded Waste Paper
D. Viggiano, D. Cuna & F. Zimbardi, ENEA, Italy
F. Alfani, M. Cantarella, L. D'Ercole, A. Gallifuoco, E. Ricci & A. Spera, University of L'Aquila, Italy
- 564 P3.13 Closed Material Cycles - Utilization of Carbon Dioxide from Industrial Exhaust Gas as Raw Material Source
O. Pulz & H. Franke, IGTV, Germany
K.-H. Steinberg & K. Menz, PREUSSAG, Germany
- 566 P3.14 Preliminary Estimations in the Production of Bioethanol from Carob
J.S. Vourdoumbas & J.A. Kaliakatsos, Technological Education Institute of Heraklion, Greece
- 568 P3.16 Circular Running Economy with Vegetable Oil
L. Iglhaut, U. Behmel & R. Meyer-Pittroff, Technical University of Munich, Germany
- 572 P3.17 Possibilities and Limits of the Re-Use of Used Cooking Oils with Animal Fat Content as Motor and Heating Fuel
H.P. Löhrllein, A. Angraini & R. Krause, University of Kassel, Germany
- 575 P3.19 Bioethanol Production from the Utilisation of Agricultural Residues of Developing Countries
D.P. Koullas, D. Mamma, D. Kekos, B.J. Macris & E.G. Koukios, National Technical University, Greece
L. Obasi & L.E. Aneke, Enugu State University of Science and Technology, Nigeria
C. Dong & C. Zheng, Sichuan Union University, P.R. China
- 578 P3.20 Development of Biofuel Production in Poland
A. Grzybek & M. Rogulska, IBMER, Poland
- 582 P3.21 High Solids Enzymatic Hydrolysis of Steam Exploded Willow without prior Water Washing
A.A. Pristavka & M. Rabinovich, Russian Academy of Sciences, Russia
P.A. Kodituvakk & Yu.P. Kozolov, Russian University of Peoples' Friendship, Russia
G. Zacchi, University of Lund, Sweden
- 586 P3.22 Enzyme Recovery in the High Solids Enzymatic Hydrolysis of Steam Pretreated Willow: Requirements for the Enzyme Complex
A.A. Pristavka & M. Rabinovich, Russian Academy of Sciences, Moscow, Russia
V.P. Salovarova, State University of Irkutsk, Russia
G. Zacchi, University of Lund, Sweden
- 590 P3.23 The Screening of Neutral Phenol Oxidase Producers Among Fungal and Actinomycetes Strains Isolated from Tropical Soils
L.G. Vasilchenko, O.V. Skorobogat'ko, E.A. Stepanova & M. Rabinovich, Russian Academy of Sciences, Russia
- 594 P3.24 Oxidationsstability of Fatty Acid Methyl Esters
H. Prankl, Federal Institute of Agricultural Engineering, Austria
H. Schindlbauer, Research Institute for Chemistry and Technology of Petroleum Products, Austria
- 598 P3.25 Biodiesel Production by Chemical or Enzymatic Esterification of Sunflower Oil
P.C. Passarinho, A.C. Oliveira, M.S. Pingarilho, S. Garcia Beirão, A. Soares Vieira & M. Fernanda Rosa, INETI/ITE, Portugal
- 602 P3.27 Carbon Dioxide Fixation to Starch and Following Co-Fermentation of Ethanol and 2,3-Butanediol by a Marine Microalga, *Chlamydomonas* sp. YA-SH-1
A. Hirano, Y. Samejima, K. Hon-Nami & S. Kunito, Tokyo Electric Power Company, Japan
Y. Ogushi, S. Hirayama & R. Ueda, Mitsubishi Heavy Industries, Japan
- 606 P3.28 Bio-Oil from Eucalyptus Wood and Sugar Cane Bagasse via Fixed-Bed Hydrolysis
J.D. Rocha & C.A. Luengo, UNICAMP, Campinas, Brazil
C.E. Snape, University of Strathclyde, United Kingdom
- 610 P3.29 Improvement of Peanut and Sunflower Using in Vitro Techniques as Potential Biofuel Resources
S. Gupta, S. Roy & A. Kumar, University of Rajasthan, India

Page

- 613 P3.30 Biofuel Production from *Jatropha Curcas*
S. Roy, University of Rajasthan, India
- 616 P3.31 Non-Edible Oil Seed Plants as Source of Energy and Biodiesel
S. Roy & A. Kumar, University of Rajasthan, India
- 620 P3.32 New Revolutionary Oil Recovery Process
Dr. R. Frische, Dr. Frische GmbH, Germany
- 623 P3.34 Standardisation of Rape Seed Oil as a Fuel in Adapted Diesel Engines
C. Kern, B. Widmann & Th. Wilharm, Technical University of Munich, Germany
- 627 P3.37 Seedoil-Related Activities and Use Options for Biofuels and Industrial Bioliquids in Countries with Soils Contaminated by the Chernobyl Accident
G.H. Vogel & S.B. Drenkard, DECON GmbH, Germany
- 631 P3.38 Production of Ethanol, Protein Concentrate and Technical Fibers from Clover/grass
S. Grass, G- Hansen, M. Sieber & P.H. Müller, SB AG, Switzerland
- 634 P3.39 Modification and Optimization of a Diesel Engine for the Operation with RME
P. Wickboldt & R. Strenziok, University of Rostock, Germany
- 638 P3.40 Utilization of Paper Mill Sludge for Cellulase Enzyme Production and in Enzymatic Hydrolysis
K. Réczey, M. Bollók, A. Brumbauer, A. Varga & T. Frankó, Technical University of Budapest, Hungary

Session P4: Biogas

- 641 P4.1 Danish Farm Scale Biogas Concepts - At the Point of Commercial Breakthrough
K. Hjort-Gregersen, Danish Institute of Agricultural and Fisheries Economics, Denmark
- 644 P4.2 Sugar Beet Flume and Wash Water Treatment by Anaerobic Filter Using Baked-Clay Support
S. Gourari & A. Achkari-Begdouri, Institut Agronomique et Vétérinaire Hassan II, Morocco
- 648 P4.4 Experiences with Industrial BTA-Biogas Plants in Germany
D.J. Korz, MAT Müll- und Abfalltechnik, Germany
- 651 P4.8 Biogas Recovery from Pig Slurry: Simplified Systems
S. Piccinini & C. Fabbri, CRPA, Italy
- 655 P4.10 Co-Digestion of Organic MSW and Slurry from Animal Husbandry
M. Hedegaard, Krüger, Denmark
V. Jaensch, Krüger, Germany
- 660 P4.11 Anaerobic Treatment of Liquid Products Produced by Thermal Hydrolysis in Fixed Bed Reactors
S. Pechtl, R. Höfler & F. Bischof, ATZ-EVUS, Germany
- 662 P4.13 Co-Digestion of Biowaste and Commercial Organic Waste
K. Hoppenheidt, W. Mücke, P. Hirsch, H. Nordsieck & M. Swerev, BIfA, Germany
H. Kübler, REA, Germany
- 667 P4.14 Power Thermal Installation for Farms
E. Kazarian, State Engineering University of Armenia, Armenia
A. Amiryany, Armenian Agricultural Academy, Armenia
- 669 P4.15 Bioreactors for Fuels and Chemicals Production - Predictive Analytical Modelling Via Microbiological and Physicochemical Synergetics
M.S. Todorovic, F. Kosi & L. Simic, University of Belgrade, New Yugoslavia
- 673 P4.17 Biogas-Technologies for Regenerative Energy Supply in Eastern Europe
E. Fugger, Research Centre Seibersdorf, Austria
- 677 P4.18 Small Biogas System for Tenerife Island Abattoir
P. Valera, F. Pérez, B. García & M. Oramas, ITER, Tenerife, Spain
L. Camarero, EIT Industrial-UPV, Sweden
J. de Miguel Garcia, MIT, Tenerife, Spain
- 681 P4.19 The Effect of Thermochemical Pretreatments for Anaerobic Biodegradability of Orange Peel
F. Taner, G. Baydar & A. Alpdogan, University of Mersin, Turkey
- 684 P4.20 Biogasanlagen in der Lebensmittelindustrie am Beispiel realisierter und geplanter Biogasanlagen in Brennereien
A.J. Gleixner, INNOVAS, Germany
- 688 P4.21 Advantages and Risks of Anaerobic Co-Fermentation
G. Langhans, Linde-KCA-Dresden, Germany

Page		
691	P4.23	Small Biogas Plants <i>O. Muck, Biotechnische Abfallverwertung, Germany</i>
694	P4.25	Hydrolysis of Microbial Waste by Temperature Activation <i>J. Schrader & D. Sell, DECHEMA, Germany</i>
698	P4.27	Cofermentation of Biomass. Technical, Organizing and Legal Possibilities for Energy Production. <i>P. Weiland, FAL, Germany</i>
702	P4.28	Utilization of Anaerobic Techniques in Finland <i>K. Hänninen & J. Rintala, University of Jyväskylä, Finland</i>
706	P4.29	Biogas Production from Wastes in Portugal - Present Situation and Perspectives <i>S. Di Bernardino, INETI, Portugal</i>
710	P4.30	Biogas in Agriculture - Potentials - Present Use- Obstacles in Germany <i>M. Köttner, Fachverband Biogas, Germany</i>
714	P4.32	Biomass Co-Fermentation in a Full-Scale Anaerobic Digester - Influence of Running Parameters <i>P. Pouech, SOLAGRO, France</i> <i>H. Fruteau, Steimuller Valorga, France</i> <i>H. Bewa, ADEME, France</i>
718	P4.34	Development of Agricultural Biogas Installations in Poland <i>W. Romaniuk & M. Rogulska, IBMER, Poland</i>
722	P4.36	AD-NETT, a Network on Anaerob Digestion <i>H. Ørtenblad, Herning Municipal Utilities, Denmark</i> <i>P. Howes, ETSU, United Kingdom</i>
725	P4.37	Biogas Production from Straw Manure <i>J. Kára, Research Institute of Agricultural Engineering, Czech Republic</i>
730	P4.39	Biogas Plants: Instruments for Sustainable Environmental Management and Integrated Rural Development <i>C.T. Lukehurst, Renewable Energy & Rural Development, United Kingdom</i>
733	P4.41	Emissions from Combined Heat and Power Couplings and Means of Reduction <i>J. Boxberger & T. Amon, ILUET, Austria</i>
737	P4.42	Standardizing, Safety Guidelines, Authorization Procedures of Agricultural Biogas Plants <i>J. Boxberger & T. Amon, ILUET, Austria</i>
740	P4.43	Cofermentation of Sludge and Organic Waste as Energy Source of Decentralized Settlements <i>P. Maurer & B. Lamberth, ISET, Germany</i>
742	P4.44	Strategy of Organic Waste Reduction Based on Natural Recycling Principles <i>G. Schober & W. Trösch, Fraunhofergesellschaft, Germany</i>
	Session P5:	Timber and Wood-Based Materials in the Building Sector
745	P5.1	Extraction Remnants as Pore Forming Agents in Bricks <i>M. Knirsch, A. Penschke, W. Ruß, R. Meyer-Pitroff & W. A. Mayer, Technical University of Munich, Germany</i> <i>H. Mörtel & S. Krebs, University of Erlangen, Germany</i>
747	P5.2	The Environmental Impact of the Use of Arable Crop Materials for Insulation <i>D.P.L. Murphy, H. Wieland & H. Behring, Institute for Agricultural Building Research, Germany</i>
749	P5.3	Thermoplastic Solid Wooden Parts <i>N. Mundigler, Internuniversitäres Forschungsinstitut für Agrarbiotechnologie, Austria</i>
750	P5.5	Wood Composite Construction Material with High Stability of Form at Elevated Temperatures <i>G. Telysheva, V. Mnuskina, T. Dizhbite & Y. Zoldners, Latvian State Institute of Wood Chemistry, Latvia</i>
753	P5.6	Obtaining of Carbon Sorbents on the Basis of Oxidized Lignosulphonates <i>G. Dobele, N. Bogdanovich, L. Kuznetsova, G. Telysheva & U. Viesturs, Latvian State Institute of Wood Chemistry, Latvia</i>
755	P5.7	Das Strohprojekt <i>B. Wintersperger, ProMotion, Germany</i>

Page

Session P6: Biomass Energy Crops and Residues

- 758 P6.1 3rd Growing Year Results of C₄ Energy Plant *Miscanthus Sinensis* in Producing Energy from Biomass
M. Acaroglu, Selçuk University, Turkey
- 761 P6.2 First Results of Investigation to Optimize the Production of Grain for Bioethanol Processing
A. Rosenberger, E. Kübler, W. Aufhammer, T. Senn & H.J. Pieper, University of Hohenheim, Germany
- 764 P6.3 Production and Distribution of Biomass for Energy Transformation and Heat Supply in Rural Areas
O. Bens, R. Bungart, K. Pönitz, B.U. Schneider & R.F. Hüttl, Brandenburg Technical University of Cottbus, Germany
- 768 P6.4 Systems for the Use of the Residues of Sugar Crop as a Renewable Fuel
A. Valdés Delgado, Agency for Science and Technology, Cuba
- 771 P6.5 The Oil Palm Tree as an Energy Crop
K.O. Lim, University Sains Malaysia, Malaysia
- 775 P6.7 Genetic Resources of *Miscanthus* and their Use in Breeding
M. Deuter & J. Abraham, TINPLANT, Germany
- 778 P6.9 Examination of the Ecological Value of *Miscanthus* Expanses - Faunistic Studies
S. Jodl & A. Eppel-Hotz, LWG, Veitshöchheim, Germany
A. Eppel-Hotz, W. Kuhn & S. Jodl, LWG, Germany
W. Münzer, LBP, Germany
- 780 P6.10 *Miscanthus*: New Cultivars and Results of Research Experiments for Improving the Establishment Rate
A. Eppel-Hotz, W. Kuhn & S. Jodl, LWG, Germany
W. Münzer, LBP, Germany
- 784 P6.11 The Suitability for Cultivation, Yield Potential and Ecological Performance of Energy Crops Grown on Various Soils in the German State of Saxony
C. Röhricht & T. Beier, Sächs. Landesanstalt für Landwirtschaft, Germany
- 787 P6.12 Biomass Feeding Systems: Handling Sugarcane Bagasse
A.C.B. Neiva & C.G. Sánchez, F.E.M. - D.E.T.F, Brazil
- 791 P6.13 Selected Aspects in Accordance and Analogy to the BIT Granulation Technology
F.W. Hochheim, E. Noiriel & J.M. Diss, Biomaterial Intern. Technology, Luxembourg
- 793 P6.14 Biomass Cultivation on Salt Affected Wastelands
P. Vasudevan & S. Satyawati, Indian Institute of Technology, India
- 796 P6.15 The Benefits of Growing Mixtures of Willow Clones to Give Disease Reduction and Increased Yield
A.R. McCracken & W.M. Dawson, Dept. of Agriculture for Northern Ireland, United Kingdom
- 800 P6.16 The Present State and Trends of the Plant Biomass Production for Energy and Industry Utilization in Czech Republik
Z. Stražil & J. Simon, Research Institute of Crop Production, Czech Republic
- 802 P6.17 Cut and Comminute Harvesters for Short Rotation Poplar - Field Tests and Model Calculations
H. Hartmann & K. Thuncke, Technical University of Munich, Germany
- 806 P6.18 Modelling the Optimization of Primary Production Costs of *Miscanthus*
P. Venturi & W. Huisman, Wageningen Agricultural University, The Netherlands
- 810 P6.19 Technical Presentation of a 200 kW Superheated Steam Dryer
J. Berghel & R. Renström, University of Karlstad, Sweden
- 815 P6.20 The Energetic Role of Portuguese Biomass Wastes
F. Pinto, I. Gulyurtlu, B.A. Coelho, & I. Cabrita, INETI-ITE-DTC, Portugal
- 819 P6.22 Biomass Crop Energy Balance
L. Pari & E. Ragno, Agric. Mechanization Research Institute, Italy
- 824 P6.23 First Tests of an *Arundo Donax* (Giant Reed) Rhizomes Harvester
L. Pari, Agric. Mechanization Research Institute, Italy
- 827 P6.25 Environmental Sustainability in Conventional Forestry Systems for Bionergy: an IEA Bioenergy Task
J. Richardson, Canadian Forest Service, Canada
P. Hakkila, Finnish Forest Research Institute, Finland
T. Smith, Forest Research Institute, New Zealand

Page	
831	P6.26 Investigations for a Physical and Chemical Description of Different Biomasses for Energy <i>R. Stülpnagel, University of Kassel, Germany</i>
835	P6.27 Use of Municipal Wastewater in Short Rotation Energy Forestry - Full-Scale Application <i>K. Hasselgren, VBB Viak, Sweden</i>
839	P6.29 A Decision Support Model for Selection of the Optimum Logistics of Biofuel Supply <i>I. Ackermann, R. Schlauderer, C. Herold, H. Jacobs, & B. Koch, Institut für Agrartechnik Bornim, Germany</i>
842	P6.30 Root-Systems of Miscanthus in Different Growing Periods <i>C. Kößler & W. Claupein, Universität für Bodenkultur Wien, Austria</i>
846	P6.31 Adaption of Cynara Cardunculus Photosynthesis to Winter Mediterranean Temperatures <i>J. Fernandez, M.D. Curt & P. Aguado, ETSI Agronomos, Spain</i>
849	P6.32 Towards a Varietal Screening of Cynara Cardunculus to Oil Production <i>J. Fernandez, M. Hidalgo, G. Sanchez, & M.D. Curt, ETSI Agronomos, Spain</i>
853*	P6.33 Interest of a Geographic Information System to Assess the Potential for Willow Short Rotation Coppice at a Low Scale Level <i>F. Goor, X. Dubuisson, & J.M. Jossart, UCL, Belgium</i>
857	P6.34 Short Rotation Coppice: Shelterbelt Effect <i>J.-M. Jossart, F. Goor & J.-F. Ledent, UCL, Belgium</i>
860	P6.35 Short Rotation Coppice Production in Belgium: Productivity Trials <i>J.-M. Jossart, X. Dubuisson, & J.F. Ledent, UCL, Belgium</i>
863	P6.36 Energy Potential of Agricultural Residues in EU <i>C.S. Panoutsou, CRES, Greece</i>
867	P6.37 Harvesting and Storage of Brassica Carinata Plantation in Northern Greece <i>E. Kipriotis, National Agricultural Research Foundation, Greece</i> <i>C.S. Panoutsou & C. Dalianis, CRES, Greece</i>
870	P6.39 Economic Viability of Energy Plantations vs. Conventional Crops in Farming Systems of Rodopi County - Thrace <i>C.S. Panoutsou & C.D. Dalianis, CRES, Greece</i> <i>E. Kipriotis, National Agricultural Research Foundation, Greece</i>
874	P6.40 Root Growth, Distribution and Biomass of Paper Sorghum and Kenaf <i>P. Gherbin & A. Pardo, University of Basilicata, Italy</i>
877	P6.41 Simulation Model to Assess the Potential and Water-Limited Biomass Productivity of Kenaf and Paper Sorghum in a Mediterranean Environment <i>M. Monteleone & P. Gherbin, University of Basilicata, Italy</i>
882	P6.42 Moisture Variations in Kenaf and Paper Sorghum Stalk Induced by Devitalising Treatments <i>P. Gherbin & C. Donadio, University of Basilicata, Italy</i>
885	P6.43 Integrated Harvesting and Use of Wood and Peat for Energy <i>T. Nyrönen & J. Silpola, Vapo Oy, Finland</i>
888	P6.44 Fuel for the Dutch 30 MW(e) Gasification Project <i>C.D. Ouwens, Province of North-Holland, The Netherlands</i> <i>A. van Dongen, NV Energy Production Company UNA, The Netherlands</i> <i>T. Simons, NV Waste Care, The Netherlands</i>
891	P6.45 Effect of the Application of Sweet Sorghum Bagasse Compost on Some Properties of a Degraded Sandy Soil <i>M.J. Negro, M.L. Solano, J.E. Carrasco, & P. Ciria, CIEMAT, Spain</i>
894	P6.48 Characteristics of Reed Canary Grass (<i>Phalaris arundinacea</i> L.) Breeding Lines Compared at Three Experimental Sites in Finland <i>H. Sankari & Timo J.N. Mela, Agricultural Research Centre of Finland, Finland</i>
897	P6.49 Incremental Effect of Additives to the Heating Value of the Light Briquettes from Wood Waste <i>G. Danon & G. Stanojevic, Faculty of Forestry, New Yugoslavia</i>
901	P6.50 European Energy Crops InterNetwork (EECI-Network) <i>R. Venendaal, D. van den Berg, & J. Vos, BTG, The Netherlands</i>

Page		
905	P6.51	Production and Use of Olive Kernel Wood in Crete <i>J. Vourdoubas, Technological Education Institute, Chania Branch, Greece</i>
908	P6.53	Suitability of Various Energy Crops as Solid Fuel for Use in Pulverized Coal Units <i>J. Maier & R. Vetter, Institut für umweltgerechte Landwirtschaften, Germany</i>
911	P6.54	Effects of a Miscanthus-Cultivation on the Soil Fertility and the Soil Water Reservoir <i>B. Boelcke, S. Beuch, & S. Zacharias, Landesforschungsanstalt für Landwirtschaft und Fischerei Mecklenburg-Vorpommern, Germany</i>
915	P6.55	New Concept for the Cultivation of Rape as a Source for Renewable Energy <i>K. Scheffer & C. von Schwerin, University of Kassel, Germany</i>
919	P6.56	Grey Alder (<i>Alnus incana</i>) as Energy Forests in Estonia <i>H. Tullus & V. Uri, Estonian Agricultural University, Estonia</i>
922	P6.57	Upgrading Agricultural Residues as Feedstocks of Electricity Generation by Gasification <i>S. Arvelakis, G. Taralas, D.P. Koullas & E.G. Koukios, National Technical University of Athens, Greece</i>
926	P6.58	Establishment and Winter Survival of 15 Miscanthus Genotypes in Southern Germany <i>J.C. Clifton-Brown, I. Lewandowski & S. Schneider, University of Hohenheim, Germany</i>
930	P6.59	EMI - European Miscanthus Improvement: The Results of the First Year of a Miscanthus Breeding Project <i>I. Lewandowski, University of Hohenheim, Germany</i>
933	P6.61	Wastes of Vegetable Fat Industry as an Additive to Straw and Wood Briquetts Improve their Properties <i>V. Sladký & P. Jevic, Research Institute of Agricultural Engineering, Czech Republic</i>
935	P6.62	Comparative Studies of Two Potential Energy Crops in Greece <i>M. Christou & C. Dalianis, CRES, Greece</i>
939	P6.64	Adaptability and Productivity of Sweet Sorghum in Northern Greece <i>E. Alexopoulou & C. Dalianis, CRES, Greece</i> <i>E. Kipriotis, National Agricultural Research Foundation, Greece</i>
943	P6.65	Growth and Productivity of Three Kenaf Varieties in Northern Greece <i>E. Kipriotis, National Agricultural Research Foundation, Greece</i> <i>E. Alexopoulou & C. Dalianis, CRES, Greece</i>
947	P6.67	Low Cost Establishment and Winter Survival of Miscanthus x Giganteus <i>K.-U. Schwarz & J.B. Kjeldsen, Institute for Agricultural Sciences, Denmark</i> <i>W. Münzer, Technical University of Munich, Germany</i> <i>R. Junge, Federal Research Center for Forestry, Germany</i>
951	P6.70	Classification of Wood Fuels in Finland <i>R. Impola, VTT Energy, Finland</i>
954	P6.71	Use of High-Speed Motion Analysis in the Development of Debarking Technology <i>T. Lappalainen & V.-J. Aho, VTT Energy, Finland</i>
958	P6.72	Development of Chain-Flail Delimiting-Debarking Technology for the Integrated Production of Wood Fuel and Pulpwood <i>V.-J. Aho & I.K. Nousiainen, VTT Energy, Finland</i>
961	P6.74	Harvest, Storage and Drying of Hemp for Energy <i>G.J. Kasper, A. Scheer, C. Sonneveld & W. Huismann, IMAG-DLO, The Netherlands</i>
965	P6.75	Heat and Power from Eucalyptus and Bagasse in Nicaragua - Part B: Results of Environmental, Macro- and Micro-Economic Evaluation <i>R. van den Broek & A. van Wijk, Utrecht University, The Netherlands</i>
969	P6.76	Leaf Phenology in the First and Second Year of Growth in a Coppice Biomass Plantation <i>W. Deraedt & R. Ceulemans, University of Antwerp, Belgium</i>
972	P6.77	The Use of Exhausted Olive Husks in the Calabrian Milk and Dairy Farming Industry <i>G. Nicoletti & C. Vena, University of Calabria, Italy</i>
976	P6.78	A Technical-Environmental Index of the Quality for the Comparison of some Biomasses <i>G. Nicoletti, University of Calabria, Italy</i>
980	P6.79	The Use of Exhausted Murk in the Calabrian Wine-Making Industry <i>G. Nicoletti, University of Calabria, Italy</i>

Page	
984	P6.80 Nitrogen Removal from a Nutrient Rich Waste-water by Salix Grown in a Soil-Less System <i>G.R. Alker & D. Riddell-Black, WRc plc, United Kingdom</i> <i>S. Smith, D. Butler & A. Butler, Imperial College of Science, Technology and Medicine, United Kingdom</i>
988	P6.81 Comparative Studies of the Ecological Production of Annual and Perennial Energy Crops <i>V. Scholz, Inst. für Agrartechnik Bornim, Germany</i> <i>R. Pagel, Lehr- u. Versuchsanstalt für integrierten Pflanzenbau, Germany</i> <i>R. Ellerbrock, Zentrum für Agrarlandschafts- und Landnutzungsforschung, Germany</i>
991	P6.82 Energy and Greenhouse Gas Balances of the Utilisation of Biogas for Energy - with a Special Focus on Transportation <i>P.S. Nielsen & K. Karlsson, Technical University of Denmark, Denmark</i> <i>J.B. Holm-Nielsen, South Jutland University Centre, Denmark</i>
995	P6.83 The Importance of Characterization of Fuel Parameters in the Investigation of Combustion and Gasification Processes of Biofuels <i>R. Samuelsson, J. Burvall & P. Igsell, Swedish University of Agricultural Sciences, Sweden</i>
999	P6.84 Combined Production of Chemicals and Biomass with Microalgae in a Closed Photobioreactor <i>A.J. de Boer & J. van Doorn, Energy Research Foundation, The Netherlands</i>
1002	P6.85 Potential and Utilization of Biomass in the Czech Republic <i>J. Jiránek, Ministry of Environment, Czech Republic</i> <i>J. Weger, Research Institute of Ornamental Gardening, Czech Republic</i>
1006	P6.86 Experiences with Giant Reeds and Perennial C ₄ Grasses in Sicily <i>L. Merlo, Conphoebus, Italy</i> <i>V. Sardo, University of Catania, Italy</i>
1009	P6.87 Systematic Errors in Biomass Energy Assessment <i>N. Steinmüller, Universität Hohenheim, Germany</i>
1013	P6.88 Storage of Logging Residues in Bales <i>R. Jirjis & P. Lehtikangas, Swedish University of Agricultural Sciences, Sweden</i>
1017	P6.89 Potential Yield of Miscanthus Sinensis in the Netherlands <i>L.M. Vleeshouwers, Wageningen Agricultural University, The Netherlands</i>
1020	P6.90 The Test Bank for Energy Crops at ITER for Deserting Coastal Areas <i>M. Oramas, F. Pérez, B. García & P. Valera, ITER, Spain</i> <i>D. Chiaramonti, ETA, Italy</i> <i>H.P. Grimm, CENET, Germany</i> <i>N. El Bassam, IFP, Germany</i>
1023	P6.91 Solar Drying Plant for Biofuels <i>G. Renner, GRESP Solare Trocknungs GmbH, Germany</i>
1027	P6.92 Assessing the Advisableness of a Non Food Crop in a Region Using a Crop Simulation Model (STICS) <i>F. Ruget & R. Delécolle, INRA, France</i> <i>X. Tayot & N. Tiers, Chambre Régionale d'Agriculture, France</i> <i>J.C. Sourie, INRA, France</i>
1031	P6.93 Drying of Willow Fuel in the Supply Chain <i>J.K. Gigger & E. Annevelink, IMAG-DLO, The Netherlands</i>
1035	P6.94 Installation for the Obtaining of Energy from Biomass <i>A. Mitroi & G.V. Roman, University of Agronomic Sciences and Veterinary Medicine, Romania</i>
1039	P6.95 Sweet-Sorghum - An Energetical Crop of the Future in Romania <i>G.V. Roman, A. Mitroi & V. Ion, University of Agronomic Sciences and Veterinary Medicine Romania</i> <i>A.M. Roman, National Institute of Meteorology and Hydrology, Romania</i>
1042	P6.96 Poplar Biomass on Fluvisols <i>P. Ivanišević, S. Rončević & Z. Galic, Poplar Research Institute, New Yugoslavia</i>
1046	P6.97 Characterization of Sorghum Potential as an Industrial and Energy Feedstock - the Influence of Crop Management <i>M.P. Duarte, A. Fernando, L. Alves, V. Amparo, S. Silva, H. Guimarães & J. Santos Oliveira, Universidade Nova de Lisboa, Portugal</i>
1050	P6.98 Development of Grasses Adapted for Production of Bioenergy <i>O. Wellie-Stephan, Deutsche Saatveredelung DSV, Germany</i>

Page	
1052	P6.99 Environmental Burdens over the Entire Life Cycle of a Biomass CHP Plant <i>G. Jungmeier, Joanneum Research, Austria</i>
1056	P6.100 Straw Collection and Delivery System Based on 75 m ³ Tanks <i>J. Jensen & T. Koch, Thomas Koch Energi AS, Denmark</i> <i>M. Parsby, MP Consult, Denmark</i>
1059	P6.101 Basic Mechanical Properties of Straw <i>M.K. Hansen & T. Koch, Thomas Koch Energi AS, Denmark</i>
1062	P6.102 In-Vitro Cultures of Different Explants of Miscanthus Sinensis, Miscanthus X Giganteus and Arundo Donax Genotypes <i>S. Tóth, G. Mix-Wagner & N. El Bassam, FAL, Germany</i> <i>C. Frahnert & M. Deuter, TINPLANT, Germany</i>
1067	P6.103 Characterization of Alentejo Biomass Wastes for Energy Production <i>F. Pinto, I. Gulyurtlu, B.A. Coelho & I. Cabrita, INETI-DTC, Portugal</i>
1071	P6.104 Miscanthus Handbook <i>M. Walsh & S. McCarthy, Hyperion Energy Systems, Ireland</i>
1075	P6.105 Demonstration of a 1 MWe Biomass Power Plant at USMC Base Camp Lejeune <i>C.R. Purvis, U.S. Environmental Protection Agency, USA</i> <i>J. Cleland, Research Triangle Institute, USA</i>
1078	P6.106 Poplar Biomass Production Depending on the Clone and Planting Space <i>J. Markovic, S. Roncevic & S. Andrašev, Poplar Research Institute, New Yugoslavia</i>
1082	P6.107 Survey of Results of Poplar Selection in the Section Leuce Duby <i>V. Gužina, G. Avramovic, S. Orlovic & B. Kovacevic, Poplar Research Institute, New Yugoslavia</i>
1085	P6.108 Quality of Wood of some Poplar Clones as a Fuelwood <i>B. Klačnja & S. Kopitovic, Poplar Research Institute, New Yugoslavia</i>
1089	P6.109 Possibilities of the Production and Energetic Application of Farm Biomass <i>H. Sonnenberg & M. Graef, FAL, Germany</i>
1092	P6.110 Potential Allowable Cut of Energy Wood - Case of Northern Savo in Finland <i>M. Pesonen & T. Määttä, Finnish Forest Research Institute, Finland</i>
1095	P6.111 Influence of the Fertilization and of the High Alkali Content of Forest Soils on the Ash and Alkali Content of Forest Biomass <i>L. Esteban, M. Fernández, E. González & J. Carrasco, CIEMAT-CEDER, Spain</i>
1099	P6.113 Biomass Production in Groundnut (Arachis Hypogae) under Stressed Conditions <i>S. Gaya Agong, Jomo Kenyatta University of Agriculture and Technology, Kenya</i>
1103	P6.114 From Plantation to Industrial Product with Poplar Sric <i>E. Cuchet, A. Berthelot & C. Couratier, AFOCEL, France</i>
1106	P6.115 Bamboo for Energy <i>A.M. Korte & N. El Bassam, FAL, Germany</i>
1110	P6.119 Greenhouse Gas Mitigation Potential of Increased Fuelwood Use in Europe in 2020 <i>H. Schwaiger, Joanneum Research, Austria</i> <i>M. Doloszeski, University of Technology, Austria</i>
1114	P6.120 The Energetic Evaluation of Primary Plant Productivity for Given Environmental Conditions <i>V.A. Mudrik, Institute of Soil Science and Photosynthesis RAS, Russia</i>
Session P7: Implementation Issues	
1117	P7.1 The Role of Renewable Energy Technologies in a Systems Approach: An Effective Promotion Strategy under Multiple Objectives Considerations <i>N. Wohlgemuth, University of Klagenfurt, Austria</i>
1121	P7.2 Cascade Utilization of Biomass: How to Cope with Ecological Limits to Biomass Use <i>H. Haberl, University of Innsbruck, Austria</i>
1125	P7.3 Integrated Management of Casuarina Equisetifolia Planting in the Niayes Zone (Sénégal): Job Creation and Environment Protection <i>M.A. Seck, Université Cheikh Anta Diop, Sénégal</i> <i>P. N'Diaye, Projet Conservation de Terroirs du Littoral, Sénégal</i> <i>A. Tamba, Centre pour le Développement Horticole ISRA, Sénégal</i>

Page		
1127	P7.4	Wood-Energy: An Incentive for the Development of Employment in the Hainaut Province (Belgium) <i>P. Lemaire & R. Vankerkove, ERBE, Belgium</i> <i>Y. Schenkel & J.-F. van Belle, CRA, Belgium</i>
1131	P7.5	Study of the Radiocaesium Cycling in Willow (<i>Salix viminalis</i> L.) - Short Rotation Energy Crops <i>A. Gommers, H. Vandenhove, Y. Thiry & C. Vandecasteele, SCK-CEN, Belgium</i> <i>E. Smolders & R. Merckx, K.U. Leuven, Belgium</i>
1135	P7.7	Process Optimization to Lower Emissions for an Urban Waste Wood Combustion Plant <i>P. Hasler, Verenum Research, Switzerland</i> <i>T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research Switzerland</i>
1139	P7.8	Determination of Averaged Pollutant Concentrations from Furnaces by Continuous Measurement of the Flue Gas Flow <i>T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland</i>
1142	P7.9	Technical and Economic Assessment of the Technologies for the Conversion of Wood to Heat, Electricity and Synthetic Fuels <i>T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland</i> <i>P. Neuenschwander & P. Hasler, Verenum Research, Switzerland</i> <i>A. Jenni, IEU, Switzerland</i> <i>R. Bühler, Umwelt & Energie, Switzerland</i>
1146	P7.10	A Method for the Visualization of Economic Data of Heat and Power Plants with Dimensionless Fuel and Capital Costs <i>T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland</i> <i>P. Neuenschwander, Verenum Research, Switzerland</i>
1150	P7.12	Non Techno-Economic Factors Influencing Fuelwood Development in 5 European Countries <i>M. Fernandes, CEEETA, Portugal</i>
1154	P7.15	Nontechnical Barriers and Driving Forces to Bioenergy Market Growth in USA, Austria and Sweden - The Role of Policy and Market Structure <i>A. Roos, Swedish University of Agricultural Sciences, Sweden</i>
1158	P7.17	Analysis of BIG-GT Cycles in the Sugar-Cane Industry <i>A.C.. Walter & R. Overend, National Renewable Energy Laboratory, USA</i>
1162	P7.18	Cost Analysis of Biomass-To-Energy Systems: A Case Study in Central Florida <i>M. Rahmani, A.W. Hodges, J.A. Stricker & C.F. Kiker, University of Florida, USA</i> <i>P. Tuohy, Wheelabrator Ridge Energy, USA</i>
1166	P7.19	Centralized Biogas Plants - Environmental Strategy for an Intensive Pig Farm Region of Portugal <i>E. d'Almeida Duarte, L. Martinez Ferreira & J.P. Oliveira Miguel, Instituto Superior de Agronomia, Portugal</i> <i>P. Vasconcelos Figueiral, Centro para a Conservação da Energia, Portugal</i>
1170	P7.20	Framework for the Environmentally Compatible Cultivation of Non-Food Crops in Bavaria under Special Consideration of Crops for Energy Use <i>G. Sutor, Technical University of Munich, Germany</i>
1173	P7.21	Energy Production from Agricultural Biomass in Greece: Synergies and Antitheses of Actors Involved in the Bioguide Project <i>C.S. Panoutsou & A. Nicholaou, CRES, Greece</i> <i>S. Rozakis, Agricultural University of Athens, Greece</i>
1177	P7.22	Effluents Integral Gestion in Swine Farm <i>M. Bao, M. Domínguez & M.I. Crespo, University of Santiago de Compostela, Spain</i>
1179	P7.23	Energy Model for the Economic Use of Biomass <i>J. Nagel, BTU Cottbus, Germany</i>
1183	P7.26	Social and Political Aspects of a Biomass-Origin Cogeneration Program - The Brazilian Experience <i>S.T. Coelho & A.C. Boa Nova, University of São Paulo, Brazil</i> <i>D. Zylbersztajn, National Oil Agency, Brazil</i>
1187	P7.28	Use of Biomass and Organic Waste - A Contribution of Agriculture to Sustainable Development? <i>L. Leible, FZK, Germany</i>
1191	P7.32	Energy from Agricultural Biomass and Effects on Rural Income and Regional Development in Thessalia, Greece <i>S. Rozakis & J.-C. Sourie, ESR-INRA, France</i>

Page		
1194	P7.34	Bioenergy Market Development Strategy for Central and Eastern European Countries <i>R. Venendaal & J. Vos, University of Twente, The Netherlands</i> <i>A. Hollingdale, Natural Resources Institute, United Kingdom</i>
1196	P7.35	Straw for Energy Production in Denmark <i>M.G. Larsen, DTI Energy, Denmark</i>
1199	P7.36	Renewable Materials - On-line <i>R. Peschers, M. Grafschmidt & R. Vetter, Institut für umweltgerechte Landwirtschaft, Germany</i>
1200	P7.37	Competitiveness of Bioenergy - One Issue, Different Logics <i>E. Ling, Swedish University of Agricultural Sciences, Sweden</i> <i>K. Lundgren & K. Mårtensén, University of Lund, Sweden</i>
1203	P7.38	The Bioscan Project <i>O. Moe, Økoplan, Norway</i>
1207	P7.41	Versatile Dissemination of Bioenergy Information in Finland <i>E. Alakangas, VTT Energy, Finland</i>
1211	P7.42	Carbon Dioxide LCA in Three SRC Power Production Systems <i>I. Sintzoff & X. Dubuisson, Université Catholique de Louvain, Belgium</i>
1215	P7.43	Wood as a Sink of Carbon and a Source of Energy in Finnish Forest Industry <i>A.O. Villa, University of Joensuu, Finland</i> <i>H.O. Malinen, Lappeenranta University of Technology, Finland</i>
1219	P7.44	Development of Bioenergy Utilisation in Latvia <i>P. Shipkova, G. Kashkarova & I. Purina, Latvian Academy of Sciences, Latvia</i>
1223	P7.46	Implementation Plans for a Biomass Power Plant in Portugal <i>J.A. Teixeira, S. Torrado, P.A. da Silva Lourenço & M.L. Galinho, PROET, Portugal</i>
1227	P7.47	Potential for Bioenergy Use in Municipal Heating Production. Charting the Markets for and Opinions about Domestic Biofuels in Small and Medium-Sized Heating Companies in Finland <i>R. Toivonen, Pellervo Economical Research Institute, Finland</i> <i>E. Toivonen, University of Helsinki, Finland</i> <i>L. Tahvanainen, University of Joensuu, Finland</i>
1231	P7.48	Public Perceptions of Bioenergy in Finland - A Survey of Three Regions <i>L. Tahvanainen & N. Kiljunen, University of Joensuu, Finland</i> <i>R. Toivonen, Pellervo Economic Research Institute, Helsinki, Finland</i>
1235	P7.49	Environmental Externalities Related to Power Production on Biogas and Natural Gas Based on the EU Externe Methodology <i>P.S. Nielsen, Technical University of Denmark, Denmark</i> <i>L. Schleisner, Risø National Laboratory, Denmark</i>
1239	P7.50	Environmental Effects of Energy Crop Cultivation <i>P. Börjesson, Lund University, Sweden</i>
1243	P7.51	Growth and Utilization of Energy Crops on Marginal and Setaside Land in Estonia and Cornwall, UK <i>C. Wilkins & L. Jenkins, University of Exeter, United Kingdom</i> <i>M. Ivask & L. Nei, Environmental Protection Institute, Estonia</i>
1247	P7.53	Institutional and Social Framework for the Development and Implementation of Bioenergy Strategy in Poland <i>G. Wisniewski, EC BREC, Poland</i>
1251	P7.55	Immission Control in Biomass Combustion Plants <i>K. Mair & H. Frieß, LfU Munich, Germany</i>
1255	P7.56	Integrated Spatial Potential Initiative for Renewable Energy in Europe - (INSPIRE) <i>S. Dagnall, ETSU, United Kingdom</i> <i>B. Hillring, Swedish University of Agricultural Sciences, Sweden</i> <i>D. Sarigiannis, Joint Research Centre, Italy</i>

- Page
- 1259 P7.58 Deserescue: Small Agro Energy Farm Scheme Implementation for Rescuing Deserting Land in Small Mediterranean Islands, Coastal Areas, Having Water and Agricultural Land Constraints. Feasibility Study.
D. Chiaramonti, ETA, Italy
H.P. Grimm, CENET, Germany
M. Cendagorta, ITER, Spain
N. El Bassam, Institut für Pflanzenbau, Germany
- 1263 P7.59 National and Regional Economic Impacts of Electricity Production from Energy Crops in the Netherlands
J. Vlasblom & R. van den Broek, Utrecht University, The Netherlands
M. Meeusen-van Onna, LEI-DLO, The Netherlands
- 1267 P7.62 Small-Scale CHP on the Basis of Biomass
M. Pogoreutz & B. Reetz, Graz University of Technology, Austria
- 1271 P7.63 The Biofuel Programme in Latvia: Experimental Background and Implementation Issues
M. Bekers & U. Viesturs, University of Latvia, Latvia
E. Gudriniece, Riga Technical University, Latvia
G. Telysheva & J. Zandersons, Latvian State Institute of Wood Chemistry, Latvia
G. Bremers, Latvian University of Agriculture, Latvia
- 1275 P7.64 Implementation of Bioelectricity in Spain: Feasibility of the Utilization of Forest and Agricultural Residues for Heat and Power Production in the Region of Castilla y León (Spain)
J. Carrasco, P. Ciria & L. Esteban, CIEMAT-CEDER, Spain
- 1279 P7.66 Potential of Biomass and Perspectives of Biomass Conversion Technologies in Ukraine
G.G. Geletuha, National Academy of Sciences, Ukraine
- Session P8: Combustion of Biomass**
- 1283 P8.4 Survey Concerning Biomass-to-Energy in Combined Heat and Power Systems and District Heating Systems in Bavaria. Engineering - Economy - Ecology
W. Ortinger, M. Fink, L. Wanner & Th. Weber, Bavarian Ministry of Food, Agriculture and Forest, Germany
- 1287 P8.6 The Preconditioning of Biomass by Briquetting Technology and the Influence on the Combustion Behaviour
K. Nende, B. Clauß, U. Böttger, TU Chemnitz, Germany
M. Gohla, H. Reimer, H. Tepper, Universität Magdeburg, Germany
W. Neidel, Neidel-Büro, Germany
- 1291 P8.8 Combustion of Rapeseed in a Heat Supply Unit for an Agricultural Training Centre
P. Schulze Lammers & K. Hentschel, Institut für Landtechnik, Germany
J. Matthias & J.P. Ratschow, Westfalian Chamber of Agriculture, Germany
- 1295 P8.9 Experience with Commissioning and Preliminary Operation of a 120 t/h - 200 bar - 540°C Straw/Wood Chip Fired Boiler Plant at Sønderjyllands Højspændingsværk, Aabenraa, Denmark
C. Ramsgaard-Nielsen, Sønderjyllands Højspændingsværk, Denmark
- 1298 P8.11 Utilization of Biomass for Heating in the Czech Republic
J. Pešat & D. Ligocká, ZDB, Czech Republic
V. Sladký & P. Jevíè, Research Institute for Agricultural Engineering, Czech Republic
- 1300 P8.12 Characterisation of Fly Ash from Co-Combustion of Biomass in a Pulverised Coal Fired Power Boiler
K. Wieck-Hansen & P. Binderup, Midtkraft, Denmark
- 1304 P8.14 Combination of Wood Fuel and Natural Gas in Domestic Heating Systems
H. Hartmann, T. Launhardt & H. Schmid, Landtechnik Weihenstephan, Germany
- 1308 P8.15 Determination of the Combustion Efficiency in Biomass Furnaces
T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland
J. Good, Verenum Research, Switzerland
- 1311 P8.16 Emissions of PCDD/F from Biomass Combustion
T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland
P. Hasler, Verenum Research, Switzerland
- 1315 P8.17 Technology and Economics of Urban Waste Wood Combustion
T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland

- Page
- 1318 P8.18 NO_x Reduction in Biomass Combustion: Primary and Secondary Measures
T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland
- 1322 P8.19 Mechanisms of Deposition Formation during Biomass Combustion
H. Kaufmann, Swiss Federal Institute of Technology, Switzerland
T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland
L. Baxter, N. Young, Sandia National Laboratories, USA
- 1326 P8.20 Characteristics and Formation of Fly Ash Particles in Biomass Furnaces
H. Kaufmann, Swiss Federal Institute of Technology, Zürich, Switzerland
T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland
- 1330 P8.22 Particle Size Distribution of the Fly Ash from Biomass Combustion
P. Hasler, Verenum Research, Switzerland
T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland
- 1334 P8.23 Indirectly Fired Gas Turbine for Rural Electricity Production from Biomass
H. Knoef, B. Wagenaar, P. Reuermann, University of Twente, The Netherlands
- 1338 P8.25 The Combined System of Production and Use of Biomass
E. Kazarian & S. Vardanyan, State Engineering University of Armenia, Armenia
- 1340 P8.26 Combustion Efficiency in Biomass Furnaces with Fluegas Condensation
J. Good & P. Neuenschwander, Verenum Research, Switzerland
T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland
- 1344 P8.27 Main Problems with Planning, Construction and Use of Wood Furnaces for Dwellings - Experience from Consulting Activities Based on Bavarian Research Projects
A. Strehler, Technical University of Munich, Germany
- 1348 P8.28 Alkali-Induced Particle Agglomeration and Bed-Defluidization on CFB-Combustion of Biomass -Test of Common and Alternative Bed Materials
F. Zintl & T. Öhmann, Termiska Processer, Sweden
- 1351 P8.29 New Concept for Thermal Waste Recycling in the Chipboard and Paper Industry
W. Kapf, Richard Kablitz & Mitthof, Germany
- 1353 P8.30 Reduction of Aerosol Particles in Flue Gases from Biomass Combustion with a Rotational Particle Separator RPS
P. Hasler, Verenum Research, Switzerland
T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland
H. Schaffner, Schmid, Switzerland
B. Brouwers, Eindhoven University of Technology, The Netherlands
- 1356 P8.31 Temperature Reduction by Fluegas Recirculation in Biomass Combustion with Air Staging, Modeling and Experimental Results
J. Good, Verenum Research, Switzerland
T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland
R. Salzmann, Swiss Federal Institute of Technology, Switzerland
O. Leiser, Tiba-Müller, Switzerland
- 1360 P8.32 NO_x Reduction in Biomass Combustion by Combination of Air Staging and SNCR Technique
J. Good, Verenum Research, Switzerland
T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland
H. Schaffner, Schmid, Switzerland
- 1362 P8.33 Efficiency Improvement and Emission Reduction by Advanced Combustion Control Technique (ACCT) with CO/Lambda Control and Setpoint Optimization
J. Good, Verenum Research, Switzerland
T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland
- 1366 P8.34 CFD Modelling of Wood Furnaces
C. Bruch, Swiss Federal Institute of Technology, Switzerland
T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland
- 1370 P8.35 Influence of Biomass Fuel Moisture to the Operating Parameters of Small-Scale Boiler with Stoker Burner
A. Veski, T. Pihu & A. Ots, Tallinn Technical University, Estonia
- 1374 P8.36 New Methods and Standardisation Possibilities of Quality Control of Biobriquette and other Bio-Fuels
P. Pecznik, L. Fenyvesi & J. Hajdú, Hungarian Institute of Agricultural Engineering, Hungary

Page	
1377	P8.37 The Reduction of Emissions from the Combustion of Biomass for Domestic Heating Applications <i>D.A. Cowburn & R.D. Holtham, CRE Group, United Kingdom</i> <i>N. Berge & M. Berg, TPS Termiska Processer, Sweden</i>
1380	P8.38 Monitoring of PAH and Chlorinated PAH in Biomass Combustion Emissions <i>A. Walte & W. Muenchmeyer, WMA Airsense Analysentechnik, Germany</i> <i>T. Launhardt, Technical University of Munich, Germany</i>
1383	P8.39 Deposits on Superheaters in Combustion of Forest Residue with and without Selected Additives <i>P. Kallner & B. Ljungdahl, TPS Termiska Processer, Sweden</i>
1387	P8.40 Biomass Use - Biomass Combustion with Coal Addition <i>D. Andert & J. Kara, Research Institute of Agricultural Engineering, Czech Republic</i>
1389	P8.41 LOW-NO _x -Furnace Engineering for Residual and Used Wood Combustion for the Improvement of Particle Burn-Out and Efficiency in Industrial Systems < 1MW <i>U. Zuberbühler & G. Baumbach, Universität Stuttgart, Germany</i>
1393	P8.42 Integration of Gas Turbine Plants with Bio-Fuels in a Regional Energy System <i>J. Adam & U. Hansen, Universität Rostock, Germany</i>
1397	P8.43 Combustion of Cork and Pine in a Fluidised Bed Combustor <i>I. Gulyurtlu, F. Figueiredo, R. Edgar & I. Cabrita, INETI, Portugal</i>
1401	P8.44 Combined Cold Heat and Power Generation Utilizing Heat From Biomass Heating Plants <i>J. Kötting & P. Ganter, Ingenieurgesellschaft für Energie- und Umwelttechnik Cramer, Ganter, Kötting, Germany</i> <i>C. Schweigler, Bayerisches Zentrum für angewandte Energieforschung, Germany</i>
1405	P8.45 Emissions of Biomass Combustion Plants <i>H. Frieß & S. Huber, Bayerisches Landesamt für Umweltschutz, Germany</i>
1409	P8.46 Biomass Energy Systems for Single Family Houses - Efficiency, Emissions and Costs <i>L. Gustavsson & Å. Karlsson, Department of Environmental and Energy Systems Studies, Sweden</i>
1413	P8.47 Additional Combustion of Biomass in the Coal-Fired Power Stations at St. Andrä and Zeltweg/Austria <i>H. Schröfelbauer, Österreichische ElektrizitätswirtschaftsAG, Austria</i> <i>J. Tauschitz, Verbund Elektrizitäts-ErzeugungsAG, Austria</i>
1417	P8.48 Identification and Quantitation of Polycyclic Aromatic Hydrocarbons in Biomass Combustion Emissions (Cynara cardunculus) <i>F. Sáez, A. Cabañas, A. González & R. Escalada, IER-CIEMAT, Spain</i>
1420	P8.49 Feasibility Study of the Fluidized Bed Combustion of Cynara cardunculus Biomass in BAFB Pilot Plant <i>J.M^d. Martinez, R. Escalada, J.M^d. Murillo & J.E. Carrasco, CIEMAT, Spain</i>
1424	P8.50 Combustion Tests of Energy Crops in Denmark <i>L. Nikolaisen, DTI Energy, Denmark</i>
1427	P8.51 Influence of Different Variables on the Combustion Behaviour of Wood <i>R. Bilbao, J.F. Mastral, J. Ceamanos & M.E. Aldea, University of Zaragoza</i>
1431	P8.52 The Heat of Reaction during Combustion of Wood <i>M.E. Aldea, J.F. Mastral, J. Ceamanos & R. Bilbao, University of Zaragoza, Spain</i>
1434	P8.53 Biomass Combustion: Influence of the Inlet NO Concentration in the Gas Reburning Process <i>R. Bilbao, L. Prada, A. Millera & M.U. Alzueta, University of Zaragoza, Spain</i>
1438	P8.55 Automatic Loading/Unloading-Systems for Large Element Silos <i>H.J. Schmid, Schmid, Switzerland</i>
1441	P8.56 Modern Log Wood Boiler with Fuzzy-Logic-Control <i>P. Hasler, Tiba, Switzerland</i>
1445	P8.57 New Developments to Optimize Heat Production Cost of Wood Furnaces <i>P. Hasler, Tiba, Switzerland</i>
1449	P8.58 Individual Kitchen Stove - Reduction of the Emissions of Carbon Monoxide and Organic Carbon <i>H. Hofbauer, Schiffert S. Rupp, Austrian Tile Stove Association, Austria</i>
1453	P8.59 Development of the Use of Mixed Fuels and Multifuels <i>T. Järvinen, VTT Energy, Finland</i>

Page		
1456	P8.60	Optimisation of the Combustion and Emission Behaviour of Wood Burning Systems - an Experimental and Numerical Approach <i>S. Unterberger, H. Knaus, H.G. Heller, U. Schnell, H. Maier & K.R.G. Hein, University of Stuttgart, Germany</i> <i>J. Sutinen, Tampere University of Technology, Finland</i>
1460	P8.61	Relevance of Combined Heat and Power Production (CHP) with Biomass <i>H. Dienhart & J. Nitsch, Deutsche Forschungsanstalt für Luft- und Raumfahrt, Germany</i>
1464	P8.62	Investigation and Optimisation of Combustion Conditions in Small Solid Fuel-Fired Heating Appliances <i>H.G. Heller, G. Baumbach & S. Unterberger, Universität Stuttgart, Germany</i> <i>M. Struschka, Ingenieurbüro Dr. Struschka, Germany</i>
1467	P8.63	A Power Plant for the Wood Processing Industry <i>R.. Neukirch, Schwörer Haus, Germany</i>
1472	P8.64	Biomass Co-Firing with Coal at Lakeland, FL, USA, Utilities <i>S.A. Segrest, The Common Purpose Institute, USA</i> <i>D.L. Rockwood, A.E.S. Green & W.H. Smith, University of Florida, USA</i> <i>J.A. Stricker, Polk County Extension Office, USA</i>
1474	P8.65	NO _x - Reduction by Primary Measures for Grate Furnaces in Combination with In-Situ Measurements in the Hot Primary Combustion Zone and Chemical Kinetic Simulations <i>A. Weissinger & I. Obernberger, Technical University Graz, Austria</i> <i>G. Längle & A. Steurer, MAWERA Holzfeuerungsanlagen, Austria</i>
1478	P8.66	Fluctuations in Combustion Systems <i>A. Malmgren & T. Nilsson, TPS Termiska Processer, Sweden</i> <i>D.J. Morgan, IFRF, The Netherlands</i>
1482	P8.67	Co-Firing Biomass and Coal - Experimental Investigations of Deposit Formation <i>H. Junker & F. Fogh, Elsamprojekt, Denmark</i> <i>L. Baxter & A. Robinson, Sandia National Laboratories, USA</i>
1486	P8.68	Comparison of Bed Combustion Characteristics of Wood Chips from Energy Coppice and from Forest Residue <i>J. Larfeldt & N. Berge, TPS Termiska Processer, Sweden</i>
1490	P8.69	First Experiences With a Fuel Feeding System for Wood Particle Fired Gas Turbines with Direct Combustion <i>A. Joppich & H. Haselbacher, Technische Universität Wien, Austria</i>
1494	P8.70	Active Flue Gas Condensation in Biomass District Heat Plans <i>E. Podesser, Joanneum Research, Austria</i>
1498	P8.71	Boiler Conversion Technologies to Biofuels Used in Estonia <i>A. Paist & Ü. Kask, Tallinn Technical University, Estonia</i>
1502	P8.72	Share of Biofuels in Energy Balance of Estonian Residential Sector <i>P. Muiste, Estonian Agricultural University, Estonia</i> <i>Ü. Kask, Tallinn Technical University, Estonia</i>
1506	P8.73	Investigations and Optimisation of Wood Burning Appliances <i>C. Gaegauf & M. Scheuble, Centre of Appropriate Technology, Switzerland</i>
1509	P8.74	Biomass Burner with Low Emissions of Particulates <i>C. Gaegauf, M. Scheuble, Centre of Appropriate Technology, Switzerland</i> <i>C. Hüglin, Eidgenössische Technische Hochschule, Switzerland</i>
1513	P8.75	The Köb "Pyrot" - Rotary Firing for Spare Wood With Automatic Charging <i>F. Wehinger, Köb & Schäfer, Austria</i>
1516	P8.76	Optimization of Design and Operation of Networks of Pipes for Biomass-Fired District Heating Plants - Phase 1: Study of Heat and Pressure Losses in Pipes <i>J. Plank & S. Demmel, Bavarian Center for Applied Energy Research, Germany</i> <i>W. Winter & I. Obernberger, BIOS Consulting, Austria</i>
1520	P8.77	Crop Residues Burning for Energy Production in a Bunch Shape <i>T. Tziricoglou, TEI of Larissa, Greece</i> <i>T.A. Gemtos, University of Thessaly, Greece</i>

Page		
1524	P8.78	Biopre: A Techno-Economic Software to Optimise Low and Medium Range Wood-Based Heating Systems <i>R. Vankerkove & P. Lemaire, ERBE Agence Régionale Biomasse Energie Gembloux, Belgium</i> <i>J.F. van Belle & Y. Schenkel, C.R.A, Belgium</i>
1527	P8.79	Newly Designed Domestic Stoves with Low Emissions and High Efficiency <i>H. Hyttiäinen, Tulisydän Oy, Vantaa, Finland</i> <i>M. Struschka, Ingenieurbüro Dr. Struschka, Weissach, Germany</i>
1530	P8.81	The Possibility of Burning Biomasses and Coal Together in the Czech Republic <i>D. Juchelková, VSB - Technical University Ostrava, Czech Republic</i>
1534	P8.83	Biomass Application for Heating the Primary Schools of a Portugese Municipalities Association <i>A. Pires, Regional Energy Agency, Vale Douro Norte, Portugal</i> <i>M. Cordeiro, UTAD University, Portugal</i>
1537	P8.84	Biomass Fuels in Reburning Technologies <i>V. Zamansky, P.M. Maly, R. Seeker & B.A. Folsom, Energy and Environmental Research Corporation, USA</i>
1541	P8.85	Practical Experience from the Planning of a Biomass Heating System <i>M. Gammel, Ingenieurbüro für Anlagentechnik, Germany</i>
1545	P8.86	Straw Fired CHP-Plant, Operational Experience, Development and Next Generation <i>V.D. Pedersen, SK Power Company, Denmark</i> <i>M. Madsen, Elkraft Power Company, Ballerup, Denmark</i>
Session P9: Advanced Thermochemical Conversion Processes and Novel Applications		
1549	P9.1	Fluidized Bed Gasification of Biomass for Cogeneration <i>M. Ising, D. Hölder, C. Backhaus & W. Althaus, Fraunhofer UMSICHT, Germany</i>
1552	P9.2	Synergies in Co-Gasification of Biomass with Coal in Pressurized Fluidized Bed Reactor <i>G. Chen, Q. Yu, C. Brage, C. Rosén & K. Sjöström, Royal Institute of Technology, Stockholm, Sweden</i>
1556	P9.3	Generation of Furfural during the Acetosolv Pulping of Eucalyptus Globulus Wood <i>V. Santos, S. Abad, J.L. Alonso & J.C. Parajó, University of Vigo, Spain</i>
1559	P9.4	Generation of Xylooligosaccharides by Mild Autohydrolysis of Eucalyptus Wood <i>H. Domínguez, J.C. Parajó & G. Garrote, University of Vigo, Spain</i>
1563	P9.5	Hemicellulose Decomposition by Hydrothermal Processing of Wood: A Kinetic Study <i>J.C. Parajó, H. Domínguez & G. Garrote, University of Vigo, Spain</i>
1567	P9.6	A Generalized Mathematical Assessment on the Behaviour of Polysaccharides during the Acetosolv Processing of Eucalyptus Globulus Wood <i>S. Abad, J.C. Parajó, V. Santos & J.L. Alonso, University of Vigo, Spain</i>
1571	P9.8	PyNe - The Pyrolysis Network <i>A.V. Bridgwater & C.L. Humphreys, K. Dowden, Aston University, United Kingdom</i>
1575	P9.10	'Small Bio-Power-Plant for Rural Application' - A Project within the EC-FAIR-Program <i>G. Falkenhain, TFH Bochum, Germany</i> <i>H. Selzer, University of Bremen, Germany</i>
1577	P9.11	Comparison of Polycyclic Aromatic Hydrocarbon Concentrations in Oils Derived from the Flash Pyrolysis of Wood and Rice Husks <i>N. Nugranad, P.A. Horne & P.T. Williams, University of Leeds, United Kingdom</i>
1581	P9.12	Rapid Pyrolysis of Agricultural Residues at High Temperatures <i>R. Zanzi, K. Sjöström & E. Björnbom, Royal Institute of Technology, Sweden</i>
1585	P9.14	The Solid Biomass Co-Generation Plant (CHP) on its Way to Marketing Maturity Exemplarily Shown on a Third-Generation Thermoprocessor Gasification Plant <i>W. Brunner, D. Böhning, R. Heidrich, Lockwood Greene Petersen GmbH, Germany</i>
1589	P9.16	Aromatic Hydrocarbons in the Catalytic Upgrading of Biomass Pyrolysis Oils in the Presence of Steam <i>P.T. Williams & N. Nugranad, University of Leeds, United Kingdom</i>
1593	P9.17	Bench Unit for Biomass Residues Torrefaction <i>F. Fonseca Felfli, C.A. Luengo & G. Bezzon, Universidade Estadual de Campinas, Spain</i> <i>P. Beaton Soler, Universida de Oriente, Cuba</i>

-
- Page
- 1596 P9.18 A Numerical Model for Biomass Torrefaction
F. Fonseca Felfli, C.A. Luengo & G. Bezzon, Universidade Estadual de Campinas, Spain
P. Beaton Soler & W. Suros Mora, Universida de Oriente, Cuba
- 1600 P9.19 Method for the Sampling and Analysis of Particles and Tars from Biomass Gasifiers
P. Hasler, Verenum Research, Switzerland
T. Nussbaumer, H. Kaufmann & R. Salzmann, Swiss Federal Institute of Technology ETH Zentrum, Switzerland
- 1604 P9.20 A Jet-Loop-Reactor for the Absorptive Treatment of Waste Waters from Biomass Gasification Processes
P. Morf, Swiss Federal Institute of Technology ETH Zentrum, Switzerland
T. Nussbaumer & P. Hasler, Swiss Federal Institute of Technology/Verenum Research, Switzerland
- 1608 P9.21 Release of Chlorine from Biomass at Gasification Conditions
E. Björkman, B. Strömberg & F. Zintl, TPS Termiska Processer, Sweden
- 1612 P9.22 Development of an Integrated Small Scale Combined Heat/Power Fixed Bed Gasification System Fuelled by Standard Gasifier Fuel
H.A.M. Knoef & H.E.M. Stassen, BTG Biomass Technology Group, The Netherlands
- 1616 P9.23 Decomposition of Tar in Pyrolysis Gas by Partial Oxidation and Thermal Cracking. Part 2.
P. Brandt & U. Henriksen, Technical University of Denmark, Denmark
- 1619 P9.24 Biomass Gasification for Small Size Electric Power Generation
D. Viggiano & D.A. Matera, E.N.E.A, Italy
S. Kultz & G. Vacca, Basilicata University, Italy
- 1623 P9.25 Particle Size Distribution of the Fly Ash from Biomass Gasification
P. Hasler, Verenum Research, Switzerland
T. Nussbaumer, Swiss Federal Institute of Technology/Verenum Research, Switzerland
- 1626 P9.26 Solar Thermal Biomass Conversion - Theoretical Investigations and Experimental Setup
V.I. Anikeev, Borekov Institute of Catalysis, Russia
- 1630 P9.27 Efficient and Economic Dust Separation from Flue Gas by the Rotational Particle Separator as an Innovative Technology for Biomass Combustion and Gasification Plants
T. Brunner & I. Obernberger, BIOS Graz, Austria
J.J.H. Brouwers, University of Twente, The Netherlands
Z. Preveden, Kohlbach Ges. m.b.H. & CoKG, Austria
- 1634 P9.28 Tar Evolution Profiles Obtained from Gasification of Biomass and Coal
C. Brage, Q. Yu, G. Chen & K. Sjöström, Royal Institute of Technology, Sweden
- 1638 P9.29 Quasi Continuous Tar Quantification with a New Online Analyzing Method
O. Moersch, H. Spliethoff & K.R.G. Hein, Universität Stuttgart, Germany
- 1642 P9.30 Improved Ablative Pyrolysis Reaction System
N.M. Robinson & A.V. Bridgwater, Aston University, United Kingdom
- 1645 P9.33 Influence of Temperature on the Ash Composition and Volatilization during Gasification and Combustion of Residual Biomass
R. Coll, J. Salvador & D. Montané, Universitat Rovira i Virgili, Spain
- 1648 P9.34 Production of Hydrogen by Catalytic Steam Reforming of Residual Streams from Biomass Conversion Processes
M. Markevich & D. Montané, Universitat Rovira i Virgilia, Spain
D. Wang & S. Czernik, National Renewable Energy Laboratory, USA
E. Chornet, National Renewable Energy Laboratory, USA and Université de Sherbrooke, Canada
- 1652 P9.35 Fuel Gas from Biomass - Utilisation Concepts
C. Greil, Lurgi Umwelt, Germany
- 1654 P9.37 Characterisation of a HZSM-5 Catalyst Used in Bio-Oil Upgrading
C. Lahousse, R. Maggi & B. Delmon, Université Catholique de Louvain, Belgium
- 1658 P9.39 Upgrading of Pyrolysis Oils by Hydrotreating: Study of the Competition between Different Oxygenated Functions
M. Ferrari, N. Bosmans, C. Lahousse, R. Maggi & B. Delmon, Université Catholique de Louvain, Belgium
- 1662 P9.40 Biomass Gasification for Electricity Production: Upgrading of Tars
C. Hörnell, C. Myrén, C. Brage, Y. Qizhuang, E. Björnbohm & K. Sjöström, Royal Institute of Technology, Sweden
-

Page	
1665	P9.41 Pressurized Gasification of Olive Waste in a Fluidized Bed Reactor <i>C. Rosén, R. Zanzi, K. Sjöström, C. Brage & Q. Yu, Royal Institute of Technology (KTH), Sweden</i>
1669	P9.42 A Fast Pyrolysis Lab Scale Plant: Setting up and Test with Miscanthus Sinensis <i>M. Bao Iglesias, J. Lamas Alvareño & M.I. Crespo Rodríguez, University of Santiago de Compostela, Spain</i>
1671	P9.43 Design and Simulation of a High Temperature Integrated Gasification Unit <i>M. Bao Iglesias, M.I. Domínguez Gondelle & M.I. Crespo Rodríguez, University of Santiago de Compostela, Spain</i>
1673	P9.44 Novel Applications for Electric Power Production by Utilisation of Purified Low Energy Gas Coming from Refuse Derived Fuel <i>G. Barducci & P. Ulivieri, TAVOLINI, Italy</i> <i>F. Repetto, ANSALDO, Italy</i> <i>F. Cristo, SAFI, Italy</i>
1677	P9.46 Development of an Integrated Process to De-ash, Fractionate and Dry Biomass <i>M.M. Benter, P.A. Orange & K.E. Scott, Converttech Group, New Zealand</i>
1681	P9.52 Where to Produce at what Price? <i>M.J.G. Meeusen-van Onna, Agricultural Economics Research Institute, The Netherlands</i>
1685	P9.53 Degradation and Detoxification of Tar Water from a Gasification Plant in a Biogas Reactor <i>I. Angelidaki & B.K. Ahring, Technical University of Denmark, Denmark</i>
1689	P9.54 Electronic Upgrading of Flash Pyrolysis Oil <i>S. Deimling, M. Jäger & J. Köhler, University of Stuttgart, Germany</i>
1693	P9.55 Gas and Electricity Production from Waste Material and Biomass via Allothermal Gasification <i>H. Kubiak & H.J. Mühlen, DMT - FuelTec, Germany</i>
1696	P9.56 Feasibility of Steam Explosion Pretreatment to Enhance Enzymatic Hydrolysis of Municipal Organic Wastes <i>I. Ballesteros, J.M. Martínez, J.M. Oliva, A.A. Navarro, J.E. Carrasco & M. Ballesteros, CIEMAT, Spain</i>
1700	P9.57 Minimisation of Sintering Tendencies in Fluidised Bed Gasification of Energy Crop Fuels <i>A.L. Hallgren & J. Oskarsson, TPS Termiska Processer, Sweden</i>
1704	P9.58 Development of Selective Oxidation Technology for the Reduction of NO _x Emission in Gasification Power Plants <i>J. Leppälähti & E. Kurkela, VTT Energy, Finland</i> <i>K. Stahl, Sydkraft AB, Sweden</i> <i>P. Kilpinen & M Hupa, Abo Akademi, Finland</i> <i>M. Cannon, European Gas Turbines Ltd. United Kingdom</i> <i>J. Nieminen, Foster Wheele Energia Oy, Finland</i>
1708	P9.59 Steam Gasification of Biomass in a Fluidized Bed. Effect of a Ni-Al Catalyst <i>L. García, M.L. Salvador, J. Arauzo & R. Bilbao, University of Zaragoza, Spain</i>
1712	P9.61 NO _x Reduction in Biomass Combustion by NH ₃ -SNCR <i>R. Bilbao, M.U. Alzueta, M. Oliva, J.C. Ibañez, L Prada & A. Millera, University of Zaragoza, Spain</i>
1716	P9.62 Production of Methyl Aryl Ethers from Biomass Flash Pyrolysis Vapors <i>M.C. Samolada & I.A. Vasalos, Chemical Process Engineering Research Institute, Greece</i>
1720	P9.63 Utilisation of Suitable Catalysts for the Gasification of Biomasses <i>S. Rapagnà, N. Jand & P.U. Foscolo, University of L'Aquila, Italy</i>
1724	P9.65 Heat and Power from Eucalyptus and Bagasse in Nicaragua: Part A: Description of Existing Initiatives <i>R. van den Broek & A. van Wijk, Utrecht University, The Netherlands</i>
1728	P9.66 A Dynamic Model of Biomass Gasification in a Circulation Fluidized Bed as a Tool for Optimising Design and Operation <i>A.I. van Berke & G. Brem, TNO Inst. of Environmental Research, The Netherlands</i> <i>M. Valk, University of Twente, The Netherlands</i>
1732	P9.67 Life Cycle Assessment of Biomass Fuels for Fuel Cell and Engine Combined Heat and Power (CHP) Production <i>M. Pehnt, DLR, Stuttgart, Germany</i>
1736	P9.68 Modeling and Simulation of Fixed-Bed Biomass Gasifiers <i>C. Di Blasi, F. Buonanno & G. Signorelli, Università degli Studi di Napoli, Italy</i>
1740	P9.69 Numerical Simulation of Biomass Pyrolysis under Fluidized-Bed Conditions <i>C. Di Blasi, Università degli Studi di Napoli, Italy</i>

Page		
1744	P9.70	Combustion Kinetics of Chars Derived from Agricultural Residues <i>C. Di Blasi, F. Buonanno & C. Branca, Università degli Studi di Napoli, Italy</i>
1749	P9.72	Pyrolysis of Biomass Briquettes, Modelling and Experimental Verification <i>B. van der Aa, G. Lammers & A.A.C.M. Beenackers, University of Groningen, The Netherlands</i>
1753	P9.73	Test of Pyrolysis Gasifier Stoves in Two 'Institutional' Kitchens in Uganda <i>P.S. Nielsen, Technical University of Denmark, Denmark</i> <i>P. Wendelbo, University of Science and Technology, Ghana</i>
1757	P9.74	Circulating Fluidized Bed Gasification Experiments at ECN <i>E. Schenk, C.M. van der Meijden, J. van Doorn & A. van der Drift, Energy Research Foundation, The Netherlands</i>
1761	P9.75	Gasification of Wood Waste from Public Gardens for CHP Production <i>L. Dinkelbach, van der Meijden, S.D. Ytsma & E. Schenk, Netherlands Energy Research Foundation, The Netherlands</i> <i>H. Klein Teeselink, HoSt v.o.f, The Netherlands</i>
1765	P9.76	Bed-Agglomeration in Fluidised-Bed Conversion of Biomass <i>F.S. Ligthart & A. van der Drift, Netherlands Energy Research Foundation, The Netherlands</i> <i>A. Olsen, Risø National Laboratory, Denmark</i>
1769	P9.77	Fluidised Bed Gasification of Eucalyptus Grown under Different Fertilisation Conditions <i>C. Franco, I. Gulyurtlu, P. Azevedo & I. Cabrita, INETI, Portugal</i>
1773	P9.78	Catalytic Pyrolysis for Bio-Oil Quality Improvement <i>E.H. Salter & A.V. Bridgwater, Aston University, United Kingdom</i>
1777	P9.82	Removal of H ₂ S from Hot Gasifier Product Gases by Means of Regenerative Sorbents <i>P. Hagström & A. Hallgren, TPS Termiska Processer, Sweden</i>
1781	P9.83	Pressurised Fluidised Bed Co-Gasification of Coal and Biomass <i>W. de Jong, K.R.G. Hein & J. Andries, TU Delft, The Netherlands</i>
1785	P9.86	In-Bed Use of Dolomite in Fluidized Bed Biomass Gasification with Air. Product Distribution and Gas Quality Improvement <i>J. Gil & M.P. Aznar, University of Saragossa, Spain</i> <i>M.A. Caballero, E. Frances J. A. Martin & J. Corella, University Complutense, Madrid, Spain</i>
1789	P9.87	Co-Shift Catalytic Beds after a Biomass Gasifier and a Steam-Reforming Catalytic Reactor to Get New and Interesting Exit Gas Compositions <i>M.A. Caballero, P. Aznar, University of Saragossa, Spain</i> <i>J.A. Martin & J. Corella & K Gil, University Complutense, Spain</i>
1794	P9.88	Advances in Catalytic Hot Gas Clean Up and Conditioning at Pilot Scale with Nickel Based Catalysts in Fluidized Bed Biomass Gasification <i>J. Corella & J.A. Martin, University Complutense, Spain</i> <i>M.P. Aznar, M.A. Caballero, J. Gil & E. Francés, University of Saragossa, Spain</i>
1798	P9.90	State and Prospects of Biomass Gasification <i>C. Rösch & M. Kaltschmitt, Universität Stuttgart, Germany</i>
1802	P9.95	Thermocatalytic Processes for Wood-Biomass and Wood-Plastic Mixtures Conversion to Liquid and Char Products <i>B.N. Kuznetsov, V.I. Sharypov, V.E. Taraban`ko & M.J. Shchipko, Institute of Chemistry & Chemical Technology SB RAS, Russia</i>
1806	P9.96	Changes in Charcoals and By-Products Characteristics through Pressurized Pyrolysis <i>S. Numazawa, P. Girard, P. Rousset & S. Mouras, CIRAD-Foret, France</i>
1815	P9.97	Chemical Conversion of Various Celluloses in Supercritical Water to Glucose <i>S. Saka & T. Ueno, Kyoto University, Japan</i>
1819	P9.99	Generators that won't wear out for Biomass Applications <i>R.M. Erbezniak & K. Colenbrander, Stirling Technology Company, USA</i>
1826	P9.100	Performance and Characteristics of a Wood Downdraft Gasifier with Vortex Gas Cleaning System <i>G. Geletuha, A. Khalatov & I. Borisov, National Academy of Sciences, Ukraine</i>

SUBERIN-BASED POLYURETHANES: SYNTHESIS, CHARACTERIZATION AND KINETICS OF THEIR FORMATION

N. Cordeiro¹, M. N. Belgacem², A. Gandini² and C. Pascoal Neto³

¹Departamento de Química, Universidade da Madeira, 9000 Funchal, Portugal

²Ecole Française de Papeterie et des Industries Graphiques (INPG), BP 65, 38402 St Martin d'Hères, France

³Departamento de Química, Universidade de Aveiro, 3800 Aveiro, Portugal

ABSTRACT

The synthesis and characterization of novel family of polyurethanes prepared by the polycondensation of suberin from *Quercus suber* L. with aliphatic and aromatic isocyanates are reported. A preliminary kinetic study, conducted with the aim of establishing the reactivity of suberin with different mono-, di- and polyisocyanates, showed that the kinetics of these condensations followed the classical second-order behaviour up to conversion of about 90%. The reactivity of different isocyanates followed patterns that could be readily rationalized in terms of steric hindrance and electronic factors associated with each specific structure. The investigation was then extended to the synthesis of the new polymers which were characterized by FTIR and NMR spectroscopy and DSC. These suberin-based polyurethanes were a mixture of linear, branched and crosslinked structures. The proportion of the latter (insoluble fraction) being the highest for the syntheses carried out in stoichiometric conditions, viz. $[NCO]_0 = [OH]_0$. The Tg of these materials depended of the diisocyanates used and correlated with their structural stiffness.

1 INTRODUCTION

For several years, we have been engaged in research dealing with the rational exploitation of wastes resulting from the transformation of the outer bark of *Quercus suber* L., commonly known as cork [1-5]. In fact, the cork industry produces about 56000 tons/year of dust and wastes without any recognized industrial interest. These rejects are presently burned for energy recovery, regardless of the fact that they could be a source of interesting chemicals or materials [1-6]. We have previously shown that an alkaline methanolysis of this by-product gives about 40% of suberin which is a mixture of aliphatic chains bearing carboxylic methyl esters and hydroxyl groups [1]. These potential macromonomer were thoroughly characterized by vapour pressure osmometry, which gave a number average molecular weight (Mn) of 800 and by GPC, which showed the existence of a low molecular-weight fraction centered around Mn=550 and a wider fraction with an Mn of about 2000. Based in the results obtained from the determination of the hydroxy number, which was about 160, we calculated an average OH functionality of 2.3 per molecule of methanolized suberin. This result incited us to investigate the use of suberin as a polyol in the syntheses of polyurethanes by polycondensation reactions with isocyanates.

This paper first reports a kinetic studies of the formation of urethane functions resulting from the reaction between suberin and conventional aliphatic and aromatic isocyanates. The influence of steric hindrance and electronic factors, linked to the specific structure of each isocyanates could thus be established. The characterization of the suberin-based polyurethanes was then conducted by spectroscopic and thermal analyses.

2 EXPERIMENTAL

The suberin used in this work was obtained by alkaline methanolysis as described in a previous study [1].

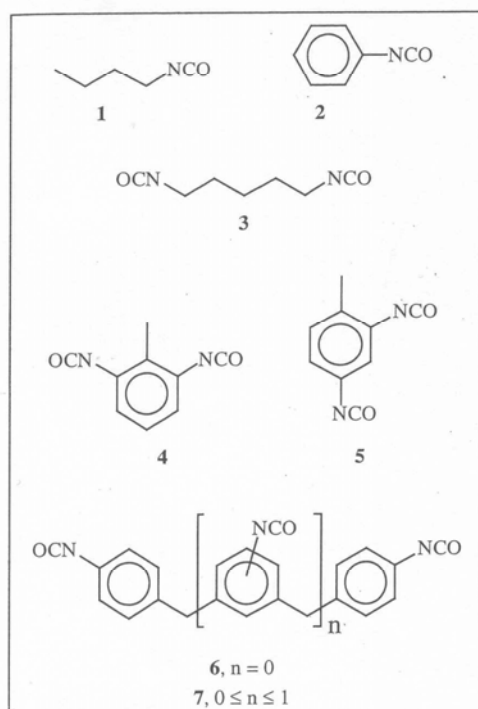
Solvents and catalysts were commercial products of the highest purity available. Isocyanates with three different functionalities (F) were used (see Scheme I):

- (i) F = 1: namely n-butyl (1) and phenyl (2) isocyanate;
- (ii) F = 2: hexamethylene- (3), 2,4- (4) and 2,6- (5) toluene diisocyanates and their 80:20 w/w mixture and diphenyl methane diisocyanate (6);
- (iii) F = 2.7: a commercial mixture of diphenyl methane diisocyanates and triphenyl methane triisocyanates (7).

For the uncatalyzed reactions, the isocyanate was added to a solution of suberin in pure dry tetrahydrofuran (THF). The initial concentration of both reagents was 0.2 M and the stoichiometric conditions were kept equal to unity, i.e. $[NCO]_0 = [OH]_0$. For the catalyzed reactions, a 10^{-2} M solution of the catalyst (dibutyltin dilaurate, DBTD) in dry THF was prepared and stored in a dry atmosphere. The suberin was dissolved in the catalyst solution before adding the isocyanate under vigorous stirring. For kinetic studies the resulting mixture was quickly poured into an FTIR liquid cell and thereafter spectra recorded at regular intervals. Between spectra, the cell was kept at the desired constant temperature. A gentle stream of dry nitrogen was maintained in all experiments. The course of the reactions were controlled by monitoring the NCO peak around 2250 cm^{-1} in the FTIR spectra and each run was stopped after total consumption of the isocyanate moieties had been reached.

Both the kinetic study and the actual preparation of polyurethane with different isocyanates were carried out in the same conditions, except for the reaction temperature for the materials' synthesis which was $70 \pm 1^\circ\text{C}$. The polyurethanes thus obtained were extracted in soxhlet

apparatus with methylene chloride, for 12 hours and the soluble and insoluble fractions weighed and examined.



Scheme I. Chemical structure of the isocyanates used in this work.

The FTIR spectra were recorded with a Perkin-Elmer Paragon 1000 spectrometer whereas the $^1\text{H-NMR}$ spectra was taken with a Bruker AMX-300 spectrometer using deuterated chloroform as the solvent of the soluble fractions and tetramethylsilane (TMS) as internal standard. The chemical shifts (δ) are given in ppm down field from TMS.

Differential scanning calorimetry (DSC) analyzes were made in sealed aluminium capsules with a Setaram DSC 92 in a stream of dry nitrogen. Sample for DSC weighed ca. 10 mg. The oven was maintained in a dry nitrogen atmosphere. Annealing was carried out by plunging the capsules in liquid nitrogen. Heating cycles were made between -150°C and $+150^\circ\text{C}$, at a rate of 10°C per minute and cooling cycles with 15°C per minute.

3 RESULTS AND DISCUSSION

3.1 Kinetic studies

The second-order treatment was the most adequate way of representing the kinetic data of these systems with all the isocyanates investigated [5]. The Lambert-Beer law was applied to the variation of the intensity of the FTIR NCO peak according to the second-order kinetic equation [5]:

$$(A_0 - A)/A = k [\text{NCO}] \quad (\text{I})$$

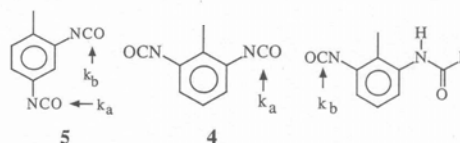
The experimental data thus obtained, processed according to equation I, showed good linearity of the second-order treatment, up to 90% conversion. In some cases, a deviation was observed at higher conversion. This phenomenon is well-documented in the literature attributed to an autocatalytic effect induced by the urethane functions and/or to the consumption of NCO by side reactions like the formation of allophanates [7].

The second-order rate constants for the uncatalyzed reactions between suberin and 1 or 2, at room temperature, were 0.25×10^{-4} and $1.5 \times 10^{-4} \text{ l mol}^{-1} \text{ s}^{-1}$, respectively. The modest reactivity of the aliphatic isocyanate compared with that of phenyl homologues and the present quantitative difference agrees with those reported in previous studies [8]. The catalyzed reactions displayed the same trends, albeit with a smaller difference in reactivity, as shown in Table I.

Table I: Second-order rate constants and activation energies for the catalyzed reactions between suberin and different isocyanates in THF at different temperatures, with $[\text{NCO}]_0 = [\text{OH}]_0 = 0.2 \text{ M}$.

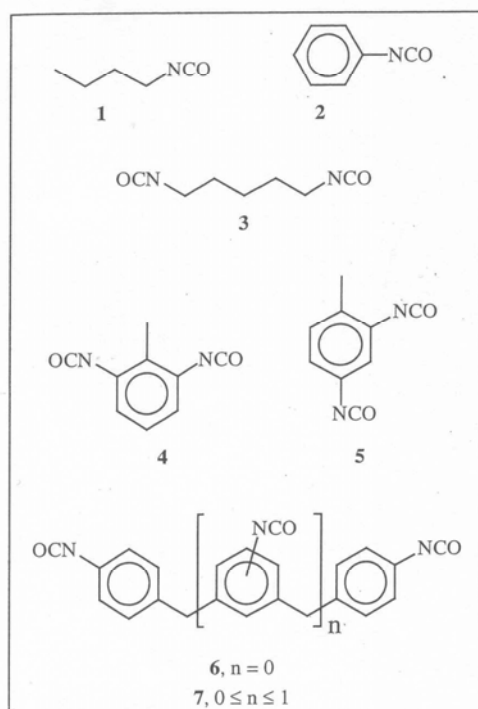
Isocyanate	Temperature ($^\circ\text{C}$)	$10^4 k$ ($\text{l mol}^{-1} \text{ s}^{-1}$)	Ea (kJ mol^{-1})
1	23	16.3	18.7
	35	22.8	
	45	27.5	
6	23	16.1	30.6
	23	5.75	
2	23	5.2	12.6
	35	6.6	
	45	12.6	

The second-order plots of asymmetric diisocyanate 5 gave two straight lines with a break in the slope (Figure 1). Therefore, the kinetic study of asymmetric diisocyanates were treated according to the competitive consecutive second-order model [9]. Two rate constants were determined, corresponding respectively to the reaction of the NCO groups at the *para* and *ortho* positions as given in Table II.



5 is an intrinsically asymmetric diisocyanate which always displays two distinct rate constants for the reaction of each functional group. 4 is symmetric in terms of chemical structure, but can become "asymmetric" after one of its NCO group has reacted because the urethane moiety and the attachment of bulky substituent can alter the reactivity of the remaining NCO moiety. This is particularly relevant here because the condensation with OH function of a suberin macromonomer chain certainly introduces steric problems for the reaction of the second NCO of 4. Table II gives the second-order rate constants and the values of the two slopes, as measured from Figure 1 for the reaction of

apparatus with methylene chloride, for 12 hours and the soluble and insoluble fractions weighed and examined.



Scheme I. Chemical structure of the isocyanates used in this work.

The FTIR spectra were recorded with a Perkin-Elmer Paragon 1000 spectrometer whereas the $^1\text{H-NMR}$ spectra was taken with a Bruker AMX-300 spectrometer using deuterated chloroform as the solvent of the soluble fractions and tetramethylsilane (TMS) as internal standard. The chemical shifts (δ) are given in ppm down field from TMS.

Differential scanning calorimetry (DSC) analyzes were made in sealed aluminium capsules with a Setaram DSC 92 in a stream of dry nitrogen. Sample for DSC weighed ca. 10 mg. The oven was maintained in a dry nitrogen atmosphere. Annealing was carried out by plunging the capsules in liquid nitrogen. Heating cycles were made between -150°C and $+150^\circ\text{C}$, at a rate of 10°C per minute and cooling cycles with 15°C per minute.

3 RESULTS AND DISCUSSION

3.1 Kinetic studies

The second-order treatment was the most adequate way of representing the kinetic data of these systems with all the isocyanates investigated [5]. The Lambert-Beer law was applied to the variation of the intensity of the FTIR NCO peak according to the second-order kinetic equation [5]:

$$(A_0 - A)/A = k [\text{NCO}] \quad (\text{I})$$

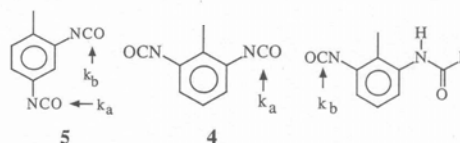
The experimental data thus obtained, processed according to equation I, showed good linearity of the second-order treatment, up to 90% conversion. In some cases, a deviation was observed at higher conversion. This phenomenon is well-documented in the literature attributed to an autocatalytic effect induced by the urethane functions and/or to the consumption of NCO by side reactions like the formation of allophanates [7].

The second-order rate constants for the uncatalyzed reactions between suberin and 1 or 2, at room temperature, were 0.25×10^{-4} and $1.5 \times 10^{-4} \text{ l mol}^{-1} \text{ s}^{-1}$, respectively. The modest reactivity of the aliphatic isocyanate compared with that of phenyl homologues and the present quantitative difference agrees with those reported in previous studies [8]. The catalyzed reactions displayed the same trends, albeit with a smaller difference in reactivity, as shown in Table I.

Table I: Second-order rate constants and activation energies for the catalyzed reactions between suberin and different isocyanates in THF at different temperatures, with $[\text{NCO}]_0 = [\text{OH}]_0 = 0.2 \text{ M}$.

Isocyanate	Temperature ($^\circ\text{C}$)	$10^4 k$ ($\text{l mol}^{-1} \text{ s}^{-1}$)	Ea (kJ mol^{-1})
1	23	16.3	18.7
	35	22.8	
	45	27.5	
6	23	16.1	
	23	5.75	
3	23	5.2	30.6
	35	6.6	
	45	12.6	

The second-order plots of asymmetric diisocyanate 5 gave two straight lines with a break in the slope (Figure 1). Therefore, the kinetic study of asymmetric diisocyanates were treated according to the competitive consecutive second-order model [9]. Two rate constants were determined, corresponding respectively to the reaction of the NCO groups at the *para* and *ortho* positions as given in Table II.



5 is an intrinsically asymmetric diisocyanate which always displays two distinct rate constants for the reaction of each functional group. 4 is symmetric in terms of chemical structure, but can become "asymmetric" after one of its NCO group has reacted because the urethane moiety and the attachment of bulky substituent can alter the reactivity of the remaining NCO moiety. This is particularly relevant here because the condensation with OH function of a suberin macromonomer chain certainly introduces steric problems for the reaction of the second NCO of 4. Table II gives the second-order rate constants and the values of the two slopes, as measured from Figure 1 for the reaction of

suberin with **4** and **5**, respectively. With both isocyanates, k_a/k_b turned out to be about 8, a figure already reported in the literature for **5** [10].

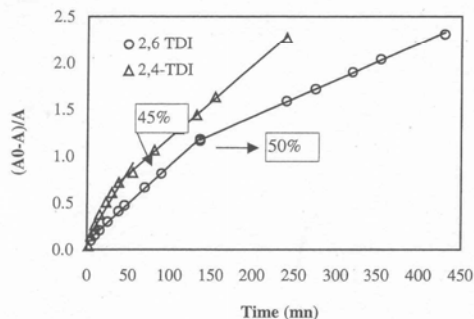


Figure 1: Second-order plot for the reaction **4** and **5** with suberin in the conditions specified in Table I at 23°C.

Table II: Second order-rate constants ($1 \text{ mol}^{-1} \text{ s}^{-1}$) and slopes of the straight lines for the reactions showed in Figure 1, according to Frost and Schwemer model.

Frost and Schwemer model [9]				
	k_a	k_b	k_a/k_b	$k_a + k_b$
4	18.1	2.1	8.6	20.2
5	11.1	1.4	7.9	12.5
Graphic data (Slopes)				
	1	2	1/2	1 + 2
4	15.3	6.7	2.3	22.0
5	6.9	3.3	2.1	10.2

The values of the slopes 1 and 2 ($1 \text{ mol}^{-1} \text{ s}^{-1}$), determined graphically, are not directly related to the individual rate constants, which are instead provided by the Frost-Schwemer treatment. However, the sum of the two slopes must be the same as the sum of k_a and k_b (see Table II).

3.2 Synthesis and characterization of products

The monourethane obtained by the reaction of suberin and **2** was with a yield of about 90% a viscous liquid. FTIR spectroscopy showed the presence of the peaks characteristic to the urethanes moieties, namely: NH, C=O and O=C-O at 3345, 1735 and 1220 cm^{-1} , respectively and the absence of those specific to the NCO groups of **2**. $^1\text{H-NMR}$ spectrum displayed mainly three groups of resonances, respectively in the regions: (i) 1.2 - 2.2 ppm corresponding to the aliphatic protons of suberin, (ii) 2.2 - 2.6 ppm representing protons of ester groups of suberin (-OCH₃); and (iii) at 6.9 - 7.5 ppm, corresponding to the aromatic protons from **2**. The DSC thermogram of this product showed an endothermic peak centered at 42°C, representing the melting point of the crystalline fraction of this suberin-based monourethane.

The use of isocyanates with functionality higher than unity, gave a mixture of linear, branched and crosslinked polymers. The extraction of these materials gave two fractions corresponding to linear and branched structures on the one hand and to the crosslinked ones, on the other hand. The influence of the $[\text{NCO}]/[\text{OH}]$ ratio for the reaction of suberin with **6** was studied in detail. As shown in Table III, of all the polymers prepared, that

corresponding to the synthesis carried out at the stoichiometric conditions $[\text{NCO}] = [\text{OH}]$ gave the highest amount of insoluble fraction.

The thermal analyses of the insoluble fractions of these suberin-aromatic polyurethanes (see Table III) showed that the glass transition temperature, T_g , reached a maximum value of 98°C again when the polymer had been prepared at stoichiometric conditions. Figure 2 shows the DSC thermogram of this suberin-**6** polyurethane before extraction and those of its soluble and insoluble fractions. The lower T_g of pristine products (about 60°C which is nearly 40°C below that corresponding to the insoluble fraction), arises from the plasticizing effect of the soluble product which has a T_g of only 42°C.

Table III: Amounts of soluble and insoluble products of the reaction between suberin and **6**, as a function of $[\text{NCO}]/[\text{OH}]$ ratio and glass transition temperature of the corresponding CH_2Cl_2 -insoluble fractions.

$[\text{NCO}]/[\text{OH}]$	Soluble products (%)	Insoluble products (%)	T_g of insoluble products (°C)
0.5	78.9	20.1	58
0.7	50.7	42.1	76
0.8	43.1	55.6	88
0.9	36.8	62.0	91
1	29.0	70.3	98
1.2	55.2	44.0	68
1.3	66.4	33.1	50

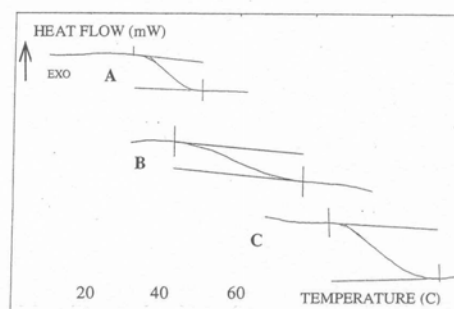


Figure 2: DSC Thermograms of the reaction products of suberin with **6** for $[\text{NCO}]/[\text{OH}]=1$ (A: soluble fraction, B: before extraction; C: insoluble fraction).

The reaction of suberin with the other isocyanates gave different polyurethanes as summarized in Table IV. The amounts of insoluble fractions are similar for all the isocyanates used, except for **7**, which has a functionality of 2.7, with which a slightly higher yield of insoluble product was observed.

Table IV: Proportions of soluble and insoluble fractions of the polyurethanes prepared from suberin and various polyisocyanates ($[NCO]_0 = [OH]_0$) and Tg of the corresponding insoluble fractions.

Isocyanates	Soluble products (%)	Insoluble products (%)	Tg of insoluble fraction (°C)
4+5 (80:20)	27.7	71.5	105
6	29.0	70.3	98
7	25.1	73.9	97
3	28.6	71.0	25

The FTIR spectra of these polyurethanes showed the presence of the peaks which arise from urethane functions (NH, C=O and O=C-O at 3345, 1735 and 1220 cm^{-1} , respectively) and the absence of peaks from possible residual NCO groups. For suberin-3 polyurethane, a strong peak corresponding to the hexamethylene moiety was detected at 2960 cm^{-1} , whereas for suberin-aromatic counterparts, the presence of the specific peaks corresponding to the differently substituted aromatic rings was ascertained in each spectrum. Figure 3 shows typical FTIR spectra for suberin-6 soluble and insoluble polyurethanes. It was systematically observed that the relative intensity of the aliphatic peaks corresponding to the soluble products were higher than those of the insoluble counterpart, comparatively to the intensity of urethane (NH peak at ca. 3350 cm^{-1}). This results from the fact that the soluble fractions of all these polyurethanes were mainly made up by the suberin macromonomer bearing fewer OH groups.

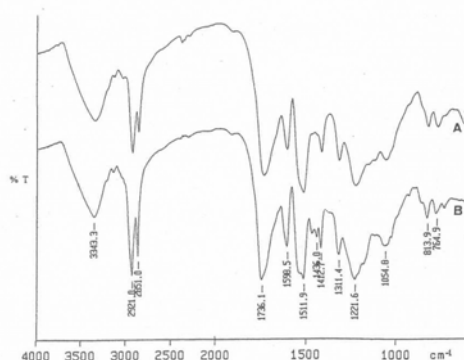


Figure 3: FTIR Spectra of the products of the reaction of suberin with 6: (A) insoluble and (B) soluble fraction.

Table IV also shows the glass transition temperature of the insoluble products corresponding to various suberin-based polyurethanes. The glass transition temperature of an amorphous polymer is an excellent probe of its chain stiffness. The presence of flexible aliphatic chains in diisocyanate 3 is therefore accompanied by a logical decrease in the Tg of the corresponding crosslinked polyurethane compared with those around 100°C, of all the aromatic-based counterparts.

4 CONCLUSION

The results obtained in the kinetic study of the polycondensations of suberin polyols with different isocyanates showed that these natural macromonomers behave in a straightforward manner in this specific context. The ensuing polyurethanes contained both thermoplastic and thermoset topologies because of the variable number of OH groups born by the suberin fragments. Depending on the type of diisocyanate used their glass transition temperature varied, thus providing the possibility of modulating their properties in accordance with the applications envisaged for these novel materials based on renewable resource.

Acknowledgements

The authors wish to thank the French-Portuguese Scientific Cooperation Program and JNICT Portugal for financial support and the Champcork Company for a kind gift of the cork samples.

REFERENCES

- [1] Cordeiro, N., Belgacem, M. N., Silvestre, A. J. D., Pascoal Neto, C. and Gandini, A. (1997). Cork suberin as a new source of chemicals. 1. Isolation and chemical characterization of its composition.", *Int. J. Biol. Macromol.*, in press.
- [2] Cordeiro, N., Belgacem, M. N., Gandini, A. and Pascoal Neto, C. (1997). Cork suberin as a new source of chemicals. 2. Crystallinity, thermal and rheological properties", *Bioresource Technology*, in press.
- [3] Cordeiro, N., Aurenry, P., Belgacem, M.N., Gandini, A. and Pascoal Neto, C. (1997). Surface properties of suberin, *J. Colloid Interface Sci.* 187, p. 498.
- [4] Cordeiro, N., Pascoal Neto, C., Gandini, A. and Belgacem, M.N. (1995). Characterization of Cork Surface by Inverse Gas Chromatography", *J. Colloid Interface Sci.* 174, p. 246.
- [5] Cordeiro, N., Belgacem, N., Pascoal Neto, C. and Gandini, A. (1997). Urethanes and polyurethanes from suberin. 1. Kinetic study, *Industrial Crops and Products*, 6, p. 163.
- [6] Pereira, H. (1988). Chemical composition and variability of cork from *Quercus suber* L., *Wood Sci. Technol.* 22, p. 211.
- [7] Entelis, S.G. and Nesterov O.V. (1966). Kinetics and mechanism of the reaction of isocyanates with compounds containing active hydrogen, *Russian Chem. Rev.*, 35, p. 917.
- [8] Belgacem, M.N., Quillerou, J., Gandini, A., Rivero, J. and Roux, G. (1989). Urethane and polyurethane bearing furan moieties-2. Comparative kinetics and mechanism of the formation of furanic and other monourethanes, *Eur. Polym. J.*, 25, p. 1125.
- [9] Frost, A.A. and Schwemer, W.C. (1952). The kinetics of competitive consecutive second-order reactions: The saponification of ethyl adipate and ethyl succinate, *J. Amer. Chem. Soc.*, 74, p. 1268.
- [10] Burkus, J. and Eckert, C.F. (1958). The kinetics of triethylamine-catalyzed reaction of diisocyanates with 1-butanol in toluene, *J. Amer. Chem. Soc.*, 80, p. 5948.