

High Biobased Carbon Content Polyurethane Dispersions Synthesized from Fatty Acid-Based Isocyanate

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ABSTRACT: A series of high biobased carbon content polyurethane dispersions (PUD) was successfully synthesized from dimer fatty acid diisocyanate (DDI), castor oil (CO), alkoxysilane-modified castor oil (MCO), and dimethylolpropionic acid (DMIPA). This work focused on the improvement for the final performance of the renewable DDI-based PUD as well as the discussion of structure/property relationships. The chemical structure of MCO and Si–O–Si cross-link network structure on the dry-film of PUD were characterized by Fourier-transform infrared spectroscopy (FTIR) and solid-state ²⁹Si NMR. The effect of alkoxysilane and NCO/OH ratio on DDI-based PUD were investigated by differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), tensile tests, and electrochemical impedance spectroscopy (EIS). The glass transition temperature, Young's modulus, and tensile strength increased with the incorporation of alkoxysilane and increasing NCO/OH ratio. In the meanwhile, the initial degradation temperature and elongation at break were reduced with increasing content of alkoxysilane. Finally, the alkoxysilane-modified DDI-based PUD exhibited excellent corrosion resistance after the immersion in NaCl solution for 28 days. In general, the present research suggested that through appropriate modification the DDI-based PUD with high biobased carbon content could exhibit great mechanical properties and excellent anticorrosion properties.



INTRODUCTION

Polyurethane dispersions (PUD) belong to the polyurethane polymer systems which are dispersed in water. They are usually synthesized from polyols, isocyanates, and the dispersing-function monomers. PUD have received extensive attention from industry and academia once they were invented. After years of research and development, PUD have become one of the most important materials in the coatings and adhesives industry due to their nontoxicity and safety.¹ Nowadays, several novel types of PUD have been developed, such as 2K polyurethanes dispersions and nonisocyanate polyurethane dispersions.^{2–4} In the next few years, the usage of PUD coatings with water as a solvent is likely to rise rapidly as the concepts of environmentally friendly development become more popular. However, compared with conventional solvent-based polyurethane coatings, there is still a need for the enhancement of biobased PUD coatings properties, such as corrosion resistance and adhesion.

Over the years, biobased materials technology has been growing rapidly. Biobased materials, especially vegetable oil-based materials, are considered potential alternatives to conventional petroleum-based materials for the future.⁵ For example, the biobased materials, such as vegetable oil-derived polyols, have been widely applied in coatings, plastic films, lubricants, rubbers, and many other intermediate products.^{6–12} Multiple synthesis methods for vegetable oil-based polyols have been investigated including epoxidation and ring opening,

transesterification and amidation, ozonolysis and reduction, hydroformylation and reduction, and thiol–ene reaction.¹³ Although some of the petroleum-based products could be replaced by biobased materials, many important petroleum-based materials rarely have suitable alternatives for real application, such as isocyanates and amines. Therefore, for sustainable development it is significant to continuously study alternatives to petroleum-based materials.

In recent years, much attention has been drawn to the application of dimer fatty acid-derived isocyanate as a potential alternative to petroleum-based isocyanate.^{14–16} 2-Heptyl-3,4-bis(9-isocyanatononyl)-1-pentylcyclohexane (DDI) is a special aliphatic diisocyanate derived from dimer fatty acid with two branched long chains connected on the cyclic aliphatic unit. It exhibits excellent flexibility, low water sensitivity, outstanding water resistance, nonyellowing performance, low toxicity, and low viscosity. Calvo-Correas reported that the thermoplastic polyurethane synthesized from DDI showed a low glass transition temperature because the branched structure of DDI could reduce the degree of crystallization.¹⁷ Chaoen developed a biobased polyurethane elastomer from DDI and biobased macrodiols with 700% of elongation at break and 40 MPa of

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Gloria, Jonathan Page**

Biobased Materials For Polyurethane Dispersions:

Conversion of Lignin into Bio-Based Chemicals and Materials Chunbao Xu, Fatemeh Ferdosian, 2017-06-05 This book presents an overview of various types of lignin and their unique structures and properties as well as utilizations of crude or modified technical lignin for high value bioproducts such as lignin based PF resins adhesives epoxy resins PF foams PU foams rubber reinforcement and carbon fibers and as dispersants in drilling fluids in the oil and gas industry It subsequently discusses various thermal chemical modification techniques pyrolysis direct liquefaction and depolymerization for converting lignin into oils and chemical feedstocks and the utilization of crude lignin lignin derived oils or depolymerized lignins DLs of reduced molecular weights and improved reactivity to produce lignin based PF resins adhesives PF PU foams and epoxy resins The book will interest and benefit a broad readership graduate students academic researchers industrial researchers and practitioners in various fields of science and technology chemical engineering biotechnology chemistry material science forestry etc Chunbao Charles Xu PhD is currently a Professor of Chemical Engineering and NSERC FPIInnovations Industrial Research Chair in Forest Biorefinery at the University of Western Ontario Canada Fatemeh Ferdosian PhD is currently a postdoctoral fellow at the University of Waterloo Canada [Sustainable Production and Applications of Waterborne Polyurethanes](#)

Sustainable Production and Applications of Waterborne Polyurethanes Inamuddin, Rajender Boddula, Anish Khan, 2021-10-20 This edited book compiles all category viewpoints in waterborne polyurethanes WPU's dispersions composites characterizing techniques and allied applications such as coatings adhesives sealants anticorrosive flame retardant and biomedical applications The book brings together panels of highly accomplished experts in the field of advanced polymers for versatile applications It encompasses basic studies and addresses topics of novel issues which cover all the aspects in one place The book is an invaluable guide to newcomers research scholars professors and R D industrial experts working in the field of polyurethane chemistry Polyurethanes are excellent materials in coating technology owing to their chemical resistance toughness abrasion resistance and mechanical stability However polyurethane dispersion contains volatile organic compounds VOCs and hazardous air pollutants HAPs which are harmful to the environment Hence green chemistry research focuses on discovery of waterborne polyurethanes WPU's and pay attention WPU's have fascinated growing interest in wide range of industrial and commercial applications *Biopolymeric Nanomaterials* Shamsheer S. Kanwar, Ashok Kumar Nadda, Tuan Anh Nguyen, Swati Sharma, Yassine Slimani, 2021-09-24 *Biopolymeric Nanomaterials Fundamentals and Applications* outlines the fundamental design concepts and emerging applications of biopolymeric nanomaterials The book also provides information on emerging applications of biopolymeric nanomaterials including in biomedicine manufacturing and water purification as well as assessing their physical chemical and biological properties This is an important reference source for materials scientists engineers and biomedical scientists who are seeking to increase their understanding of how polymeric nanomaterials are being used for a range of biomedical and industrial applications Biopolymeric nanomaterials refer to biocompatible

nanomaterials consisting of biopolymers such as protein silk collagen gelatin casein zein and albumin protein mimicked polypeptides and polysaccharides chitosan alginate pullulan starch and heparin Biopolymeric nanomaterials may be used as i delivery systems for bioactive compounds in food application ii for delivery of therapeutic molecules drugs and genes or for iii tissue engineering Provides information on the design concepts and synthesis of biopolymeric nanomaterials in biomedical and industrial applications Highlights the major properties and processing methods for biopolymeric nanomaterials Assesses the major challenges of producing biopolymeric nanomaterials on an industrial scale

Renewable Resources for Surface Coatings, Inks and Adhesives Rainer Höfer, 2022-11-11 Providing a detailed survey of renewable raw materials for paints inks and glues this book is ideal for researchers and practitioners working in the areas of green chemistry industrial chemistry and sustainability Beginning with a brief history of coatings and adhesives this book walks the reader through the chemistry properties sourcing and processing of a number of renewable raw materials including lipids natural resins proteins and carbohydrates Their use in a range of recent developments and concepts from material protection to decorative paints and coatings adhesives and sealants is highlighted providing the reader with a complete and modern foundation to the field

Bio-Based Building Materials - Proceedings of ICBBM 2025 Sofiane Amziane, Romildo Dias Toledo Filho, M'hamed Yassin Rajiv da Gloria, Jonathan Page, 2025-06-11 This book gathers peer reviewed contributions presented at the 6th International Conference on Bio Based Building Materials ICBBM held in Rio de Janeiro Brazil on June 17 20 2025 Focusing on bio based building materials 3BM as well as their applications in sustainable building constructions the contributions highlight the latest findings in this fast growing field addressing topics such as natural fibres and aggregates ramped earth innovative hybrid composites based on bio based ingredients novel sustainable binders energy efficiency aspects and life cycle analysis of these materials

Biomass Processing for Sustainable Circular Economy Hafiza Shukor, Muaz Mohd Zaini Makhtar, Abu Zahrim Yaser, 2025-07-07 This book explores the pivotal role of biomass processing in catalyzing a sustainable circular economy highlighting its ability to convert waste into useful materials It offers a wide spectrum of topics from Malaysia s biomass use to bioenergy supply chains and cutting edge extraction technologies for bioactive compounds Key bioconversion strategies like enzyme and single cell protein production via biorefineries and green biosynthesis of solvents and chemicals are explored in detail The book describes innovative low cost biomimetic technologies using Black Soldier Fly and Compost Worms bioelectrochemical systems fueled by biomass and the use of biomass in food technology The book further describes activated carbon production from wastewater treatment hydrocarbons in high liquids using co pyrolysis and vegetable oils as renewable raw materials for polyurethane biobased foam The primary themes include sustainability engineering and economic sustainability with explorations of the latest trends and innovations in the processing of biomass The use of biomass in circular economy principles its transformation into renewable sources of energy and its incorporation in various sectors are also explained Through new technologies and eco friendly strategies this book is

a necessity for researchers business professionals and policymakers committed to the innovation of biomass based solutions

Specialty Polymers Ram K. Gupta,2023-01-31 This comprehensive volume provides current state of the art information on specialty polymers that can be used for many advanced applications The book covers the fundamentals of specialty polymers synthetic approaches and chemistries to modify their properties to meet the requirements for special applications along with current challenges and prospects Chapters are written by global experts making this a suitable textbook for students and a one stop resource for researchers and industry professionals Key Features Presents synthesis characterization and applications of specialty polymers for advanced applications Provides fundamentals and requirements for polymers to be used in many advanced and emerging areas Details novel methods and advanced technologies used in polymer industries Covers the state of the art progress on specialty polymers for a range of advanced applications **Key Engineering**

Materials VI Alexander M. Korsunsky,Chobin Makabe,Haider F. Abdul Amir,Tjokorda Gde Tirta Nindhia,2016-08-15 Selected peer reviewed papers from the 6th International Conference on Key Engineering Materials ICKEM 2016 March 12 14 2016 Hong Kong China *Advanced Functional Materials and Nanotechnology* Rolando T. Candidato, Jr.,German Clavijo Mejia,Pawel Sokolowski,2023-11-16 Selected peer reviewed extended articles based on abstracts presented at the 2022 International Conference on Advanced Functional Materials and Nanotechnology ICAFMN 2022 Aggregated Book

Advances in Environmental Technologies III Ji Zhao,Aijie Wang,Xin Yong Li,Xiao Yi Wang,2014-06-18 Selected peer reviewed papers from the 2014 International Conference on Energy and Environmental Protection ICEEP 2014 April 26 28 2014 Xi an China *Building a Bio-based Economy in the 21st Century*,1998 *Annual Book of ASTM Standards* ASTM International,American Society for Testing and Materials,2004 *Biobased Smart Polyurethane Nanocomposites* Nirranjan Karak,2017-08-15 Polyurethane nanocomposites present an attractive and sustainable way for designing smart materials that can be used in packaging health and energy applications Biobased Smart Polyurethane Nanocomposites brings together the most recent research in the field from the basic concepts through to their applications Special emphasis is given to sustainable biodegradable polyurethane nanocomposites with hyperbranched architecture The book introduces biobased polyurethanes and the nanomaterials that can be used as nanocomposites followed by the resulting polyurethane nanocomposites The second part then explores important applications in paints and surface coatings shape memory self healing self cleaning biomaterials and packaging materials Written by a leading expert on polyurethane nanocomposites the book is a great introduction to this smart material and its applications **Chemistry and Industry**,2008 *Eco-Friendly Waterborne Polyurethanes* Ram K. Gupta,Ajay Kumar Mishra,2022-01-24 The polyurethane industry is among the fastest growing with polyurethanes used in consumer as well as industrial sectors Waterborne polyurethanes WPU exhibit many advantages over conventional volatile organic compounds VOCs based polyurethanes and have emerged as an environmentally friendly alternative WPU offer an opportunity to use sustainable raw materials to produce environmentally

sustainable polymers particularly polyols derived from vegetable oils Eco Friendly Waterborne Polyurethanes Synthesis Properties and Applications provides state of the art knowledge of the synthesis application and property enhancement of WPU's Covers various types of eco friendly materials and technologies used to synthesize WPU's Presents an overview and applications of WPU's in several advanced research areas Provides fundamentals of synthetic processes and their chemistries for specific applications Elaborates on advanced approaches used to convert renewable resources into polymers Offers new direction to scientists researchers and students to better understand the chemistry technologies and applications Written for polymer chemists materials scientists and other researchers and industry this book serves as a comprehensive reference for readers interested in the development and application of sustainable polymers **Research & Development** ,2007-05

R & D ,2007 Chemical Abstracts ,1994-03-07 **Vegetable Oil Based Green Organic Coatings** Cheng Zhang (Chemical engineer),2021 In recent years bio based materials technology is developing rapidly Bio based materials especially vegetable oil based materials are considered as the potential alternatives to conventional petroleum based materials in the future For example vegetable oil derived polyols have been widely applied in coatings plastic films lubricants rubbers elastomers and many other intermediate products Although some of the petroleum based products could be replaced by bio based materials many important petroleum based materials have rarely suitable alternatives for the industrial application Therefore from a sustainable point it is significant to continuously study the alternatives to petroleum based materials for coating development In this work three projects of vegetable oil based green organic coatings were investigated In Chapter 3 a self healing coating contained vegetable oil based epoxy ester as the healing agent was designed to improve the self healing function In Chapter 4 a waterborne polyurethane coating with improved mechanical property and corrosion resistance was synthesized from vegetable oil based isocyanate In Chapters 5 to 7 the fundamental structure property relationships for non isocyanate polyurethane NIPU coatings synthesized through green approaches were studied In Chapter 3 poly urea formaldehyde PUF microcapsules containing vegetable oil based epoxy ester were successfully synthesized through in situ polymerization Self healing coatings were prepared by embedding PUF epoxy ester microcapsules in the epoxy coatings The scratched self healing coating can provide good recovery of the corrosion resistance compared with the neat epoxy coating These findings demonstrated that the vegetable oil based epoxy ester is applicable for anticorrosive smart self healing coatings as a healing agent In Chapter 4 the waterborne polyurethane coatings were synthesized from dimer fatty acid diisocyanate DDI Previous reports showed they were challenging for the inadequate mechanical property which is due to the high flexibility of a long fatty acid chain on DDI This problem had been solved in this study by incorporating an alkoxy silane group into vegetable oil based waterborne polyurethane coatings This enhancement was mainly caused by the formation of a Si O Si network structure from the alkoxy silane group Additionally the alkoxy silane modified DDI based polyurethane dispersion showed outstanding corrosion resistance due to the formation of a Si O Si network structure The

significantly improved mechanical property and anticorrosion property extended the potential application of DDI based material in waterborne polyurethane coatings In Chapter 5 green waterborne two components 2K NIPU epoxy hybrid coatings were synthesized from renewable cyclic carbonate fatty acid amine amine based internal dispersion agent and waterborne epoxy chain extender Then the thermal and mechanical properties were studied The synthesized waterborne 2K NIPU showed the excellent balance of the mechanical strength and elongation at break which revealed that the rigid NIPU could be tailored by introducing fatty acid amine as a soft segment Furthermore in Chapter 7 to develop a more effective method for the preparation of waterborne NIPU coatings a series of the waterborne one component 1K NIPU coatings were synthesized from the amine based internal dispersion agent fatty acid amine bisphenol A diglycidyl ether DGEBA cyclic carbonate and multiple epoxy resins including DGEBA trimethylolpropane triglycidyl ether and 4 4 Methylenebis N N diglycidylaniline Besides in Chapter 6 the NIPU tetraethyl orthosilicate TEOS hybrid coatings were successfully prepared from amine terminated NIPU bisphenol A BPA epoxy and TEOS The anti corrosion performance of environmentally friendly NIPU coatings was significantly enhanced by the sol gel chemistry of TEOS The results revealed that the organic phase NIPU cannot provide enough compatibility for inorganic phase TEOS Therefore phase separation occurs at the interface between the aggregation phase and the continuous phase As a result incorporating TEOS into NIPU coating can be an effective approach to improve the anti corrosion performance of NIPU coating In general the successfully synthesized vegetable oil based self healing coating waterborne polyurethane coating waterborne 2K and 1K NIPU epoxy hybrid coating are the green alternatives to conventional petroleum based coatings The green vegetable oil based coatings with great performance would expand their potential industrial application and promote the replacement of petroleum materials by green materials

Soybeans Lawrence A. Johnson,2008 This comprehensive new soybean reference book disseminates key soybean information to drive success for soybeans via 23 concise chapters covering all aspects of soybeans from genetics breeding and quality to post harvest management marketing and utilization food and energy applications U S domestic versus foreign practices and production methods The most complete and authoritative book on soybeans Features internationally recognized authors in the 21 chapter book Offers sufficient depth to meet the needs of experts in the subject matter as well as individuals with basic knowledge of the topic

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