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Showkat Ahmad Bhawani
Anish Khan
Mohmad Nasir Mohmad Ibrahim
Mohammad Jawaid *Editors*

Vegetable Oil-Based Composites

Processing, Properties and Applications

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Mohammad Jawaid, Laboratory of Biocomposite Technology, Universiti Putra Malaysia, INTROP, Serdang, Malaysia

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Editors
Showkat Ahmad Bhawani
Faculty of Resource Science and Technology
Universiti Malaysia Sarawak
Kota Samarahan, Malaysia

Anish Khan
Center of Excellence for Advanced Materials Research
King Abdulaziz University
Jeddah, Saudi Arabia

Mohmad Nasir Mohmad Ibrahim
School of Chemical Sciences
Universiti Sains Malaysia
George Town, Malaysia

Mohammad Jawaid
Institute of Tropical Forestry and Forest Products
Universiti Putra Malaysia
Serdang, Malaysia

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Preface

This book provides solid, quantitative descriptions and reliable guidelines, reflecting the maturation and demand of the field and the development of vegetable oil-based composites. This book focuses on the different vegetable oils used for the preparation of composites such as olive oil and canola oil. The coverage of the book highlighted the most exciting fillers used in the preparation of vegetable oil-based composites. This book will be of interest to researchers working in the fields of composite materials, material science, applied science, and bio-wastes. This book will be useful for scientists working on the preparation of composite materials from natural sources. This book will be very helpful for students in the development of green and sustainable composite materials, as well as graduates in material science, chemical engineering, and biocomposite materials.

The first introductory chapter "Introduction to Vegetable Oils" covers the basic information about vegetable oils and their application, and the second chapter "Vegetable Oil Based Polymer Composites—Processing Properties and Applications" provides information about the processing and applications of vegetable oil composites. Chapters "Olive Oil Based Composites" and "Canola Oil as a Bio-additive: Properties, Processing and Applications" covers the use of olive oil and canola oil for the preparation of various composites. Chapters "Vegetable Oil Based Polyurethane Composites" and "Vegetable Oil Based Epoxy Composites" describe the polyurethane and epoxy-based vegetable oil composites and their applications. Chapters "Fiber Reinforced Vegetable Oil Based Vinyl Polymer Composites" and "Natural Fiber Reinforced Vegetable Oil Composites" covers the use of various fibres in the processing of vegetable oil composites. The last two chapters "Vegetable Oil Based Nanoclay Composites" and "Carbon Nanotube and Graphene-Reinforced Vegetable Oil-Based Nanocomposites" describe about vegetable oil composites based on nano clay, carbon nanotubes and graphene-reinforced materials.

Finally, we assure the readers that the information provided in this book can serve as a very important tool for anyone working on vegetable oil composites. We are grateful to all the authors who contributed chapters to this book and who helped to turn our thoughts into reality. Lastly, we are grateful to the Springer team for their continuous support at every stage to make it possible to publish on time.

Kota Samarahan, Malaysia — Showkat Ahmad Bhawani
Jeddah, Saudi Arabia — Anish Khan
George Town, Malaysia — Mohmad Nasir Mohmad Ibrahim
Serdang, Malaysia — Mohammad Jawaid

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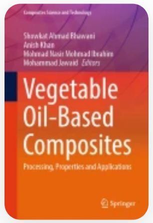

Vegetable Oil-Based Composites

Abul Hasnat, Abdul Moheman, Mohd Amil Usmani, Showkat Ahmad Bhawani & Khalid Mohammed Alotaibi

Part of the book series: Composites Science and Technology ((CST))

Abstract

Natural renewable resources are increasingly being used in the synthesis of innovative polymeric materials due to their diverse features and eco-friendliness. Among them, vegetable oil is widely available and relatively inexpensive throughout the world. Numerous polymeric materials have been developed using vegetable oil as the starting material. These materials have received prominent applications in the diverse fields of biomedical, bioengineering, and other industrial arenas. Several medications have been performed in order to augment applications with advanced materials, such as the incorporation of metals, metalloids, organic moieties, grafting of suitable materials, and blending with other polymeric materials. The addition of a small fraction of nanomaterial to polymers has been found to significantly increase the performance of pristine polymers. The purpose of this chapter is to provide an overview of some important vegetable oil-based polymer nanocomposites using graphene and carbon nanotubes and their derivatives as reinforcement materials.

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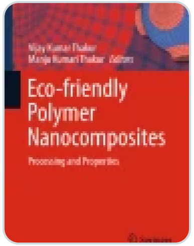

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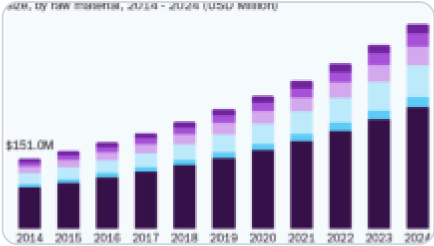

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Abbreviations

CNTs: Carbon nanotubes

EG: Extended graphite

FTIR: Fourier transform infrared

G: Graphene

GO: Graphene oxide

GR: Graphene reinforced

IPDI: Isophorone diisocyanate

IV: Iodine value

MDI: Methylene diphenyl diisocyanate

MWCNTs: Multi-walled carbon nanotubes

PUs: Polyurethanes

SEM: Scanning electron microscope

SWCNTs: Single-walled carbon nanotubes

TDI: Toluene diisocyanate

TEM: Transmission electron microscope

Tg: Glass transition temperature (Tg)

XRD: X-ray diffraction

References

1. Sharma V, Kundu PP (2006) Addition polymers from natural oils—a review. Prog Polym Sci 31:983–1008

   Google Scholar

2. Meier MAR, Metzger JO, Schubert US (2007) Plant oil renewable resources as green alternatives in polymer science. Chem Soc Rev 36:1788–1802

   Article CAS PubMed Google Scholar

3. Sharmin E, Zafar F, Akram D, Alam M. Ahmad S (2015) Recent advances in vegetable oil based environment friendly coatings: a review. Ind Crops Prod 76:215–229

   Google Scholar

4. Guner FS, Yagci Y, Erciyes AT (2006) Polymers from triglyceride oil. Prog Polym Sci 31:633–670

   Article Google Scholar

5. Samarth NB, Mahanwar PA (2015) Modified vegetable oil based additives as a future polymeric material-review. Open J Org Polym Mater 5:1–22

Article Google Scholar

6. Lochab B, Varma IK, Bijwe J (2012) Sustainable polymers derived from naturally occurring materials. AMPC 2:221–225

Article Google Scholar

7. Ahamad S, Ahmad SA, Hasnat A (2016) Synthesis and characterization of methyl methacrylate modified poly(ester-amide) resins from *Melia azedarach* seed oil as coating materials. Mater Sci Res India 13:50–56

Article CAS Google Scholar

8. Ahamad S, Ahmad SA, Hasnat A (2015) Synthesis and characterization of styrenated poly (ester-amide) resin from *Melia azedarach* seed oil-an eco-friendly resource. Chem Sci Trans 4:1047–1053

CAS Google Scholar

9. Gallegos AMA, Carrera SH, Parra R, Keshavarz T, Iqbal HMN (2016) Bacterial cellulose: a sustainable source to develop value-added products- a review. BioResources 11:5641–5655

Article CAS Google Scholar

10. Alam M, Akram D, Sharmin E, Zafar F, Ahmad S (2014) Vegetable oil based eco-friendly coating materials: a review article. Arab J Chem 7:469–479

Article CAS Google Scholar

11. Chowdhury A, Anthony P (2016) A review on biodegradable polymeric materials derived from vegetable oils for diverse applications. Int J Sci Res 5:1786–1791

Google Scholar

12. Ahmad S, Haque MM, Ashraf SM, Ahmad S (2004) Urethane modified boron filled polyesteramide: a novel anti-microbial polymer from a sustainable resource. Eur Polym J 40:2097–2104

Article CAS Google Scholar

13. Adekunle KF (2015) A review of vegetable oil-based polymers: synthesis and applications. Open J Polym Chem 5:34–40

Article CAS Google Scholar

14. Ahamad S, Imran G, Ahmad SA, Hasnat A (2015) Synthesis and characterization of polyesteramide urethane derived from meliaazedarach seed oil. Orient J Chem 31:1169–1173

Article CAS Google Scholar

15. Hasnat A (2018) Vegetable oil and its significance in sustainable development in Emerging trends of plant physiology for sustainable crop production (eds Abbas Z, Tiwari AK, Kumar P), Apple Academic Press Inc. Canada, pp 69–85 (ISBN13: 978-1-77188-636-9).

Google Scholar

16. Titirici MM et al (2022) The sustainable materials roadmap. J Phys Mater 5:032001

Article Google Scholar

17. Grozdanov A, Gentile G, Avella M, Dobreva T, Kotsilkova R (2019) Nanocomposite coatings based on alkyd resin with TiO_2 and SiO_2 nanoparticles. Material Sci Eng 3:210–215

Google Scholar

18. Zhanga C, Garrison TF, Madboulyd SA, Kesslerb MR (2017) Recent advances in vegetable oil-based polymers and their composites. Prog Polym Sci 71:91–143

Article Google Scholar

19. Deka H, Karak N (2009) Vegetable oil-based hyperbranched thermosetting polyurethane/clay nanocomposites. Nanoscale Res Lett 4:758–765

Article CAS PubMed PubMed Central Google Scholar

20. Sharmin E, Zafar F, Akram D, Ahmad S (2013) Plant oil polyol nanocomposite for antibacterial polyurethane coating. Prog Org Coat 76:541

Article CAS Google Scholar

21. Gogoi P, Boruah M, Bora C, Dolui SK (2014) Jatropha curcas oil based alkyd/epoxy resin/expanded graphite (eg) reinforced bio-composite: evaluation of the thermal, mechanical and flame retardancy properties. Prog Org Coat 77:87–93

Article CAS Google Scholar

22. Wang C, Zhang Y, Lin L, Ding L, Li J, Lu R, He M, Xie HF, Cheng RS (2015) Thermal, mechanical, and morphological properties of functionalized graphene-reinforced bio-based polyurethane nanocomposites. Eur J Lipid Sci Tech 117:1940–1946

Article CAS Google Scholar

23. Jlassi K, Chehimi MM, Thomas S (eds) (2017) Clay polymer nanocomposites, ISBN: 978–0-323-46153-5 Elsevier

Google Scholar

24. Diez-Pascual AM, Rahdar A (2021) Composites of vegetable oil-based polymers and carbon nanomaterials. Macromol 1:276–292

Article CAS Google Scholar

25. Diez-Pascual AM (2021) State of the art in the antibacterial and antiviral applications of carbon-based polymeric nanocomposites. Int J Mol Sci 22:10511

Article CAS PubMed PubMed Central Google Scholar

26. Díez-Pascual AM, Díez-Vicente AL (2016) Poly(propylene fumarate)/polyethylene glycol-modified graphene oxide nanocomposites for tissue engineering. ACS Appl Mater Interfaces 8:17902–17914

Article PubMed Google Scholar

27. Islam MR, Beg MDH, Jamari SS (2014) Development of vegetable oil based polymers. J Appl Polym Sci 131:40787–40799

Article Google Scholar

28. Ahmad S, Ashraf SM, Naqvi F, Yadav S, Hasnat A (2003) A polyesteramide from pongamia glabra oil for biologically safe anticorrosive coating. Prog Org Coat 47:95–10220

Article CAS Google Scholar

29. Konwar U, Karak N, Mandal M (2009) *Mesua ferrea* L seed oil based highly thermostable and biodegradable polyester/clay nanocomposites. Polym Degrad Stab 94:2221–2230

Article CAS Google Scholar

30. Konwar U, Das G, Karak N (2011) *Mesua ferrea* L seed oil based highly branched polyester and epoxy blends and their nanocomposites. J Appl Polym Sci 121:1076–1085

Article CAS Google Scholar

31. Babu R, Connor KO, Seeram R (2013) Current progress on bio-based polymers and future trends. Prog Biomater 2:1–16

Article Google Scholar

32. Lligadas G, Ronda JC, Galia M, Cadiz V (2013) Renewable polymeric materials from vegetable oils: a perspective. Mater Today 16:337–343

Article CAS Google Scholar

33. Petrovic ZS (2008) Polyurethanes from vegetable oil. Polym Rev 48:109–155

Article CAS Google Scholar

34. Protsaka I, Tertykha V, Pakhlova E, Derylo-Marczewskaca A (2017) Modification of fumed silica surface with mixtures of polyorganosiloxanes and dialkyl carbonates. Prog Org Coat 106:163–169

Article Google Scholar

35. Alam M, Alandis NM, Ahmad N (2017) Development of poly(urethane-ester)amide from corn oil and their anticorrosive studies. Int J Polym Anal Charact 22:281–293

Article CAS Google Scholar

36. Alam M, Alandis NM, Ahmad N, Alam MA Sharmin E (2019) Jatropha seed oil derived poly(esteramide-urethane)/fumed silica nanocomposite coatings for corrosion protection. Open Chem 17:206–219

Google Scholar

37. Silverstein RM, Bassler GC, Morril TC (1991) Spectroscopic identification of organic compounds, 5th edn. John Wile y & Sons, New York

Google Scholar

38. Pavia DL, Lampman GM, Kriz GS, Vyvyan JR (2011) Spectroscopy, 5th edn. Cengage Learning, India

Google Scholar

39. Ali A, Yusoh K, Hasany SF (2014) Synthesis and physicochemical behaviour of polyurethane-multiwalled carbon nanotubes nanocomposites based on renewable castor oil polyols. J Nanomater 2014:1–9

Google Scholar

40. Zhang CQ, Vennerberg D, Kessler MR (2015) In situ synthesis of biopolyurethane nanocomposites reinforced with modified multiwalled carbon nanotubes. J Appl Polym Sci 132:1–8

Article CAS Google Scholar

41. Wang CS, Chen XY, Xie HF, Cheng RS (2011) Effects of carbon nanotube diameter and functionality on the properties of soy polyol-based polyurethane. Compos Part A 42:1620–1626

Article Google Scholar

42. Rana S, Karak N, Cho JW, Kim YH (2008) Enhanced dispersion of carbon nanotubes in hyperbranched polyurethane and properties of nanocomposites. Nanotechnol 19:495707

Article Google Scholar

43. Liang K, Shi SQ (2010) Soy-based polyurethane foam reinforced with carbon nanotubes. Key Eng Mater 419–420:477–480

Google Scholar

44. Kumar R, Tiwari RS, Srivastava ON (2011) Scalable synthesis of aligned carbon nanotubes bundles using green natural precursor: neem oil. Nanoscale Res Lett 6:92/1–6

Google Scholar

45. Suriani AB, Azira AA, Nik SF, Nor RM, Rusop M (2009) Synthesis of vertically aligned carbon nanotubes using natural palm oil as carbon precursor. Mater Lett 63:2704–2706

Article CAS Google Scholar

46. Paul S, Samdarshi SK (2011) A green precursor for carbon nanotube synthesis. New Carbon Mater 26:85–88

Article CAS Google Scholar

47. Zhang C, Garrison TF, Madbouly SA, Kessler MR (2017) Recent advances in vegetable oil-based polymers and their composites. Prog Polym Sci 71:91–143

Article CAS Google Scholar

48. Thakur S, Karak N (2013) Bio-based tough hyperbranched polyurethane-graphene oxide nanocomposites as advanced shape memory materials. RSC Adv 3:9476–9482

Article CAS Google Scholar

49. Miyagawa H, Mohanty AK, Drzal LT, Misra M (2005) Nanocomposites from biobased epoxy and single-wall carbon nanotubes: synthesis, and mechanical and thermophysical properties evaluation. Nanotechnol 16:118–124

Article CAS Google Scholar

50. Thielemans W, McAninch IM, Barron V, Blau WJ, Wool RP (2005) Impure carbon nanotubes as reinforcements for acrylated epoxidized soy oil composites. J Appl Polym Sci 98:1325–1338

Article CAS Google Scholar

Author information

Authors and Affiliations

Department of Chemistry, Gandhi Faiz-E-Aam College (Affiliated to Mahatma Jyotiba Phule Rohilkhand University), Shahjahanpur, Uttar Pradesh, India

Abul Hasnat, Abdul Moheman & Mohd Amil Usmani

Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Kota Samarahan, Sarawak, Malaysia

Showkat Ahmad Bhawani

Department of Chemistry, College of Science, King Saud University, Riyadh, Kingdom of Saudi Arabia

Khalid Mohammed Alotaibi

Corresponding author

Correspondence to Abdul Moheman .

Editor information

Editors and Affiliations

Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Kota Samarahan, Malaysia

Showkat Ahmad Bhawani

Center of Excellence for Advanced Materials Research, King Abdulaziz University, Jeddah, Saudi Arabia

Anish Khan

School of Chemical Sciences, Universiti Sains Malaysia, George Town, Malaysia

Mohmad Nasir Mohmad Ibrahim

Institute of Tropical Forestry and Forest Products, Universiti Putra Malaysia, Serdang, Malaysia

Mohammad Jawaid

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