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Specific crosslinking effects of poly(epichlorohydrin)-triol on urethane polymer matrix of castor seed oil-based coatings

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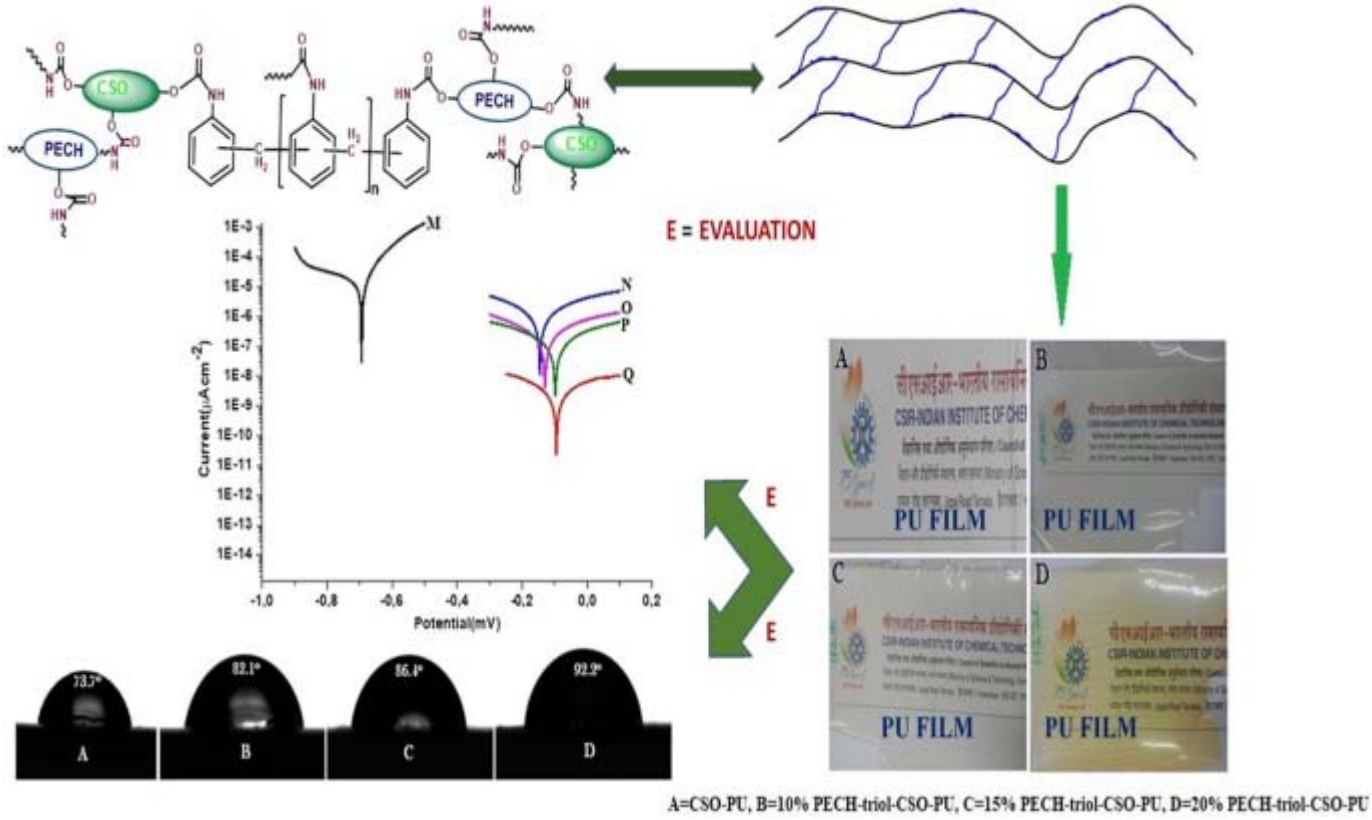
Abstract

The contributions of castor seed oil (CSO) as a useful, nontoxic, and sustainable base material for coating systems cannot be overemphasized. This paper took advantage of the predominant fatty acid composition in CSO (i.e., ricinoleic acid). It blended a synthesized crosslinker, poly(epichlorohydrin-triol) (PECH-triol), in percentages within its polymeric matrix. Physicochemical and spectroscopic (FTIR, ^{1}H-NMR, and ^{13}C-NMR) examinations were carried out on the polyols. Thermal stability, hydrophobicity, anticorrosion, mechanical, and antibacterial properties of the prepared polyurethane (PU) coatings were examined. The 20% PECH-triol–CSO-PU film having its T_{ON} and T_{END} at 230.5

and 511.0°C, respectively, showed improved thermal stability when compared with the pristine film (CSO-PU). The derivative of TGA reveals a three-stage degradation step. Hydrophobicity was seen to increase from 73.3° to 92.2°, a reflection of the crosslinking effect of PECH-triol within the urethane matrix. The improved adhesion of 20% PECH-triol–CSO-PU coating on mild steel gave a better chemical resistance.

Graphic abstract



A=CSO-PU, B=10% PECH-triol-CSO-PU, C=15% PECH-triol-CSO-PU, D=20% PECH-triol-CSO-PU

References

1. 1.

Padma, LN, "Natural Oil-Based Polymers: Opportunities and Challenges." *Polym. Rev.*, **40** (1) 1–21 (2000)

Google Scholar

2. 2.

Lu, Y, Larock, RC, “Novel Polymeric Materials from Vegetable Oils and Vinyl Monomers: Preparation, Properties, and Applications.” *ChemSusChem*, **2** (2) 136–147 (2009)

CAS Article Google Scholar

3. 3.

Siyanbola, TO, Ajanaku, KO, James, OO, Olugbuyiro, JAO, Adekoya, JA, “Physico-Chemical Characteristics of Industrial Effluents in Lagos State, Nigeria.” *J. Pure Appl. Sci.*, **1** 49–54 (2011)

Google Scholar

4. 4.

Siyanbola, TO, Sasidhar, K, Anjaneyulu, B, Kumar, KP, Rao, BVSK, Narayan, R, Olaofe, O, Akintayo, ET, Raju, KVSN, “Anti-microbial and Anti-corrosive Poly (Ester Amide Urethane) Siloxane Modified ZnO Hybrid Coatings from *Thevetia peruviana* Seed Oil.” *J. Mater. Sci.*, **48** (23) 8215–8227 (2013)

CAS Article Google Scholar

5. 5.

Erhan, SZ, *Industrial Uses of Vegetable Oils*, 1st ed. AOCS Publishing, Champaign, IL (2005)

Book Google Scholar

6. 6.

Siyanbola, TO, Sasidhar, K, Rao, BVSK, Narayan, R, Olaofe, O, Akintayo, ET, Raju, KVSN, "Development of Functional Polyurethane-ZnO Hybrid Nanocomposite Coatings from *Thevetia peruviana* Seed Oil." *J. Am. Oil Chem. Soc.*, **92** (2) 267–275 (2015)

CAS Article Google Scholar

7. 7.

Sharmin, E, Ashraf, SM, Ahmad, S, "Epoxidation, Hydroxylation, Acrylation and Urethanation of *Linum usitatissimum* Seed Oil and Its Derivatives." *Eur. J. Lipid Sci. Technol.*, **109** (2) 134–146 (2007)

CAS Article Google Scholar

8. 8.

Thomas, A, "Fats and Fatty Oils." In: Othmer, K (ed.) *Ullmann's Encyclopedia of Industrial Chemistry*. Wiley, Weinheim (2000)

Google Scholar

9. 9.

Hong, DY, Blackmore, S, *Plants of China: A Companion to the Flora of China*. Cambridge University Press, Cambridge (2015)

Book Google Scholar

10. 10.

Siyanbola, TO, Akinsola, AF, Obanla, OR, Adebisi, AA, Akinsiku, AA, Olanrewaju, IO, Ogunniran, KO, Taiwo, OS, Ajanaku, KO, Bamgboye, OA, "Studies on the Antibacterial and Anticorrosive Properties of Synthesized Hybrid Polyurethane Composites from Castor Seed Oil." *Rasayan J. Chem.*, **10** (3) 1003–1014 (2017)

CAS **Google Scholar**

11.11.

Eroglu, MS, Guven, O, "Spectroscopic and Thermal Characterization of Poly(Glycidyl Azide) Converted from Polyepichlorohydrin." *J. Appl. Polym. Sci.*, **60** (9) 1361–1367 (1996)

CAS **Article** **Google Scholar**

12.12.

Francis, AU, Venkatachalam, S, Kanakavel, M, Ravindran, PV, Ninan, KN, "Structural Characterization of Hydroxyl-Terminated Polyepichlorohydrin Obtained Using Boron Trifluoride Etherate and Stannic Chloride as Initiators." *Eur. Polym. J.*, **39** (4) 831–841 (2003)

CAS **Article** **Google Scholar**

13.13.

Mohan, YM, Raju, MP, Raju, KM, "Synthesis, Spectral and DSC Analysis of Glycidyl Azide Polymers Containing Different Initiating Diol Units." *J. Appl. Polym. Sci.*, **93** (5) 2157–2163 (2004)

CAS **Article** **Google Scholar**

14.14.

Kim, J, Shin, TK, Choi, HJ, Jhon, MS, "Miscibility of Biodegradable Synthetic Aliphatic Polyester and Poly(Epichlorohydrin) Blends." *Polymer*, **40** (24) 6873–6876 (1999)

CAS **Article** **Google Scholar**

15.15.

Kim, J, Lim, ST, Choi, HJ, Jhon, MS, "Rheological and Mechanical Characterization of Biodegradable Aliphatic Polyester and Poly(Epichlorohydrin) Blends." *Macromol. Chem. Phys.*, **202** (12) 2634–2640 (2001)

CAS **Article** **Google Scholar**

16.16.

Misiev, TA, *Powder Coatings Chemistry and Technology*. Wiley, New York (1991)

Google Scholar

17.17.

Zafar, F, Ashraf, SM, Ahmad, S, "Air Drying Polyesteramide from a Sustainable Resource." *Prog. Org. Coat.*, **51** (3) 250–256 (2004)

CAS **Article** **Google Scholar**

18.18.

Javni, I, Petrović, ZS, Guo, A, Fuller, R, "Thermal Stability of Polyurethanes Based on Vegetable Oils." *J. Appl. Polym. Sci.*, **77** (8) 1723–1734 (2000)

CAS **Article** **Google Scholar**

19.19.

Somisetti, V, Allauddin, S, Narayan, R, Raju, KVSN, "Flexible, Hard, and Tough Biobased Polyurethane Thermosets from Renewable Materials: Glycerol and 10-Undecenoic Acid." *J. Coat. Technol. Res.*, **15** (1) 199–210 (2018)

CAS Article Google Scholar

20.20.

Huang, TC, Su, YA, Yeh, TC, Huang, HY, Wu, CP, Huang, KY, Chou, YC, Yeh, JM, Wei, Y, "Advanced Anticorrosive Coatings Prepared from Electroactive Epoxy-SiO_2 Hybrid Nanocomposite Materials." *Electrochim. Acta*, **56** (17) 6142–6149 (2011)

CAS Article Google Scholar

21.21.

Arukula, RA, Thota, A, Rao, CRK, Narayan, R, Sreedhar, B, "Novel Electrically Conducting Polyurethanes with Oligoanilines: Synthesis, Conductivity, and Electrochemical Properties." *J. Appl. Polym. Sci.*, **131** (18) 40794 (2014)

Article Google Scholar

22.22.

Tallman, DE, Spinks, G, Dominis, AJ, Wallace, GG, "Electroactive Conducting Polymers for Corrosion Control Part 1. General Introduction and a Review of Non-ferrous Metals." *J. Solid State Electrochem.*, **6** (2) 73–84 (2002)

CAS Article Google Scholar

23.23.

Spinks, GM, Dominis, AJ, Wallace, GG, Tallman, DE, “Electroactive Conducting Polymers for Corrosion Control Part 2. Ferrous Metals.” *J. Solid State Electrochem.*, **6** (2) 85–100 (2002)

CAS Article Google Scholar

24.24.

Thota, A, Arukula, A, Narayan, R, Rao, CRK, Raju, KVSN, “Energy Storage and Surface Protection Properties of Dianiline Co-polymers.” *RSC Adv.*, **5** (129) 106523–106535 (2015)

CAS Article Google Scholar

25.25.

Siyanbola, TO, Neelambaram, P, Mohanty, S, Somisetti, V, Basak, P, Narayan, R, Raju, KVSN, “The Effects of Carbonized *Eucalyptus globulus* Leaves on Castor Seed Oil Based Urethane Coating System.” *Prog. Org. Coat.*, **131** 42–48 (2019)

CAS Article Google Scholar

26.26.

Stern, M, Geary, AL, “Electrochemical Polarization: I. A Theoretical Analysis of the Shape of Polarization Curves.” *J. Electrochem. Soc.*, **104** (1) 56–63 (1957)

CAS Article Google Scholar

27.27.

Girija, TC, Sangaranarayanan, MV, “Investigation of Polyaniline-Coated Stainless Steel Electrodes for Electrochemical Supercapacitors.” *Synth. Metals*, **156** (2–4) 244–250 (2006)

CAS Article Google Scholar

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