Abstract

To expand the potential functions of high-performance bio-based polymers in the green society, organic/inorganic composites of these polymers were developed and tested for their suitable applications. The selected bio-based polymers in this study were biopolyamides (BPA) and biopolyimide (BPI). A multifunctional monomer, 4,4'-di(trimethylamino)-α-truxillic acid (Q-4ATA), was synthesized by the quaternarization of bio-based 4-aminocinnamic acid (4ACA) and was polymerized with various diamines to obtain a series of cationic BPA. All cationic BPA possessed high thermal properties, with 10% weight loss temperatures of 296 – 329 °C. One application of these cationic BPA bearing quaternary ammonium was the anion-exchange ability. They were employed to remove iodide (I^-) from the water. PA-R4 was highlighted as an entirely bio-based cationic polyamide as its precursors being Q-4ATA and the glucose diamine derivatives. It was calculated to have more than 95% use of renewable sources in the sustainability metric. With 120 min equilibrium time, more than 80% adsorption of 10 mg/L initial I^- concentration in 90 °C was confirmed. The ability of BPA to perform stable anion-exchange processes in various conditions has made them a new, sustainable, and promising system for anionic pollution remediation in water. For BPI, the flame retardant films having high optical transparency were developed from amino acid-based BPI salt with aluminum (BPI-COOAl) and copper ions (BPI-COOCu). The microscale combustion calorimetry analysis revealed that BPI-COOAl possessed high flame retardancy with 4.5 kJ/g total heat released and 427 s time to ignition. At the same time, high transparency of more than 80 % transmittance at a light wavelength of 450 nm and 64 MPa tensile strength were retained. The total heat released of 14.6 kJ/g and 47 MPa tensile strength were observed in BPI-COOCu. The char formation of Al_2O_3 and Cu_2O in their respective polymer complexes was deduced as main flame suppression mechanism. Comparing to the flame retardant films in the literature, the present films of BPI salts are advantageous in terms of flame retardancy and thermo-mechanical stability. Lastly, BPI complex containing the carboxylate europium (BPI-COOEu) was produced with europium ions. Under 330 nm ultraviolet excitation, BPI-COOEu yielded emission bands at 579, 592, 616, 650 and 692 nm which were associated with the $^5D_0 \rightarrow {}^7F_J$ ($J = 0 – 4$) transition of Eu^{3+}. The prominent band at 616 nm resulted in red emission that could be observed by naked eyes. The VOCs sensor application was tested, and the enhancements and quenchings in emission bands were detected after BPI-COOEu was left in contact with solvents.

Keywords: Polyamide; Polyimide; Ion-exchange; Flame Retardancy; Photoluminescent