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Bio-based thermosetting epoxy foam: Tannic acid valorization toward dye- decontaminating and thermo-protecting applications

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Bio-resourced thermosetting epoxy foam was synthesized to valorize a sustainable natural product (i.e., tannic acid) toward two different applications e.g., dye-decontaminating and thermo-insulating. Thus, an epoxidized tannic acid (ETA) foam was produced without use of organic volatile compounds or flammable foaming gases. The ETA rigid foam was characterized in terms of physical and thermal properties. The foam density, thermal conductivity and closed-cell content were examined. The polyhedral and closed-cell structure of the foam was also explored by scanning electron microscopy. Furthermore, thermo-stability was investigated to study the impact of the aromatic structure provided by tannic acid, which resulted in high char yield (49% in N2 and 48.3% in air) at 600 oC accompanied by high LOI (37.1 in N2 and 36.8 in air). The high thermo- stability and intumescent char yield along with low thermal conductivity makes the foam to be a promising thermoset for being used as an insulating material. Additionally, sorption of methylene blue (MB, as a model pollutant) onto ETA foam was kinetically investigated. The influence of contact time, ionic strength, solution pH, initial sorbate concentration and desorption were studied, which revealed the strong dependency of the sorption process to pH and initial sorbate concentration. The experimental data fitted well with the Langmuir isotherm (R2 = 0.997), yielding a maximum sorption capacity of 36.25 mg/g. The kinetic data pointed out that MB sorption could be represented by the pseudo second-order model. Overall, the novel ETA foam can be introduced as a candidate for removing cationic pollutants, thermal insulating applications, and self- extinguishing/intumescent materials.

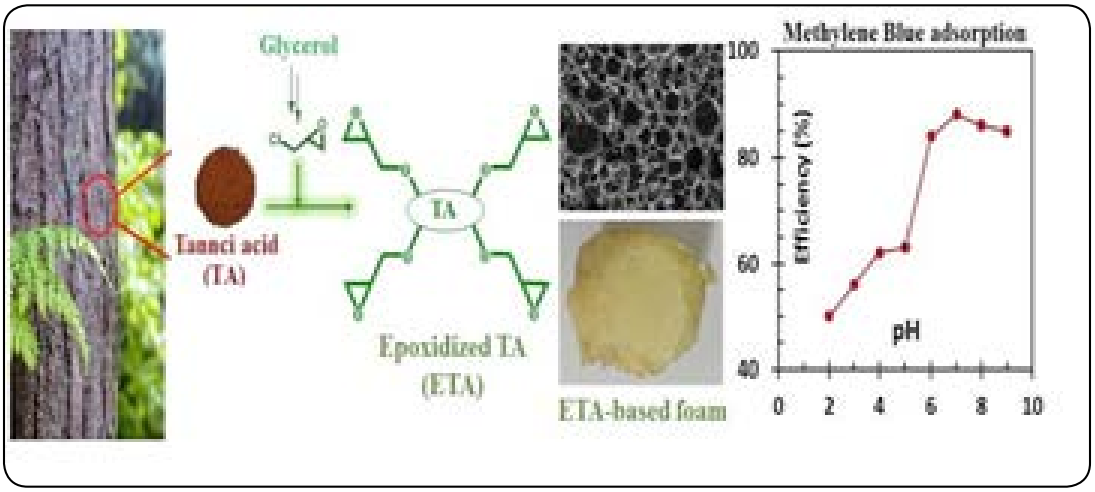

Figure 1. Tannic acid valorization toward epoxy foam and MB. sorption dependency on pH.

Recent Publications

1. Altuna FI, Ruseckaite RA, Stefani PM (2015) Biobased. Thermosetting Epoxy Foams: Mechanical and Thermal Characterization. ACS Sustainable Chemistry & Engineering 3:1406–1411.
2. Xu Q, Wang Y, Jin L, Wang Y, Qin M (2017) Adsorption of Cu (II), Pb (II) and Cr (VI) from aqueous solutions using black wattle tannin-immobilized nanocellulose. Journal of Hazardous Materials 339:91–99.

3. Lang X, Shang K, Wang Y-Z, Schiraldi DA (2015) Low flammability foam-like materials based on epoxy, tannic acid, and sodium montmorillonite clay. Green Materials 3:43–51.
4. Tondi G, Pizzi A, Olives R (2008) Natural tannin-based rigid foams as insulation for doors and wall panels. Maderas Cienciay Tecnologia 10:219–227.
5. Esmaeili N, Vafayan M, Salimi A, Zohuriaan-Mehr MJ (2017) Kinetics of curing and thermo-degradation, antioxidizing activity, and cell viability of a tannic acid based epoxy resin: From natural waste to value-added biomaterial. Thermochimica Acta 655:21-33.

Biography

Naser Esmaeili is a PhD student in the field of bio-based materials and polymer chemistry. His master thesis was about 5-(hydroxymethyl)furfural (HMF) synthesis from fructose and preparation of urea-HMF thermoset resin as a green replacement for UF resin. Now, as a PhD student, he is focusing on bio-based thermoset polymers derived from natural polyphenolic materials such as tannins. He has done some deep evaluation of the synthesized polymers as thermal insulating material, intumescent, wastewater remediation etc.

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