Functionalization of Softwood Kraft Lignin for Ion-Exchange Resin

Hyolee Choi[1], Ting-Feng Yeh[1], Sunkyu Park[1*]
[1]*Department of Forest Biomaterials, North Carolina State University, USA*

Abstract
Ion-exchange resins play a critical role in applications such as water purification, chemical separations, and environmental remediation. Conventional resins, typically synthesized from petroleum-derived polystyrene, present challenges due to their reliance on nonrenewable feedstocks and associated environmental burdens. In this work, we investigate kraft lignin (KL), a renewable aromatic biopolymer obtained from softwood pulping, as a sustainable precursor for strongly acidic cation-exchange resins. KL was first subjected to acidic phenolation to increase available reactive sites, then copolymerized with 5-hydroxymethylfurfural (5-HMF), a biomass-derived crosslinker, to form a stable resin network. Subsequent sulfonation with sulfuric acid imparted the required ion-exchange functionality. The structural and physicochemical characteristics of the resin were analyzed using Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS), and thermogravimetric analysis (TGA). The prepared lignin-based resin exhibited ion-exchange performance on par with commercial polystyrene-based resins, highlighting its promise as an eco-friendly alternative for diverse industrial processes.

Keywords: Kraft lignin, Cation-exchange resin, Lignin valorization