Lignin coating as a sustainable replacement for perfluorinated compounds in molded fiber and packaging products

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Abstract

Alternatives to perfluoroalkyl and polyfluoroalkyl substance (PFAS) for application in food packaging and molded fiber products are critically needed. PFAS offer excellent water and oil barrier properties, however, they pose significant environmental and human health risks and are being phased out in several U.S. states. Surface coating with bio-based polymers is an emerging approach to confer the desired barrier properties to molded fiber packaging. Lignin, a renewable polyphenolic macromolecule that comprises 15% to 30% of biomass, is an appealing sustainable polymer, due to hydrophobic nature. Although abundant in paper and pulp industry, most of lignin is currently used as low-cost fuel rather than in value-added applications like additives and adhesives. Our study explores the use of lignin as a potential replacement to PFAS. Technical lignin was functionalized with siloxyl groups to enhance their hydrophobic and oleophobic properties while maintaining the mechanical properties, as confirmed by various spectroscopy analyses. The results demonstrated that paper coated with modified lignin exhibited improved performance, with water contact angle >90° and oil contact angle >60°. Additionally, the Young's modulus and tensile strength of paper coated with modified lignin were significantly higher than those of paper coated with unmodified lignin. These results highlight the hydrophobic and oleophobic nature of modified lignin and suggest a promising approach to improving the barrier and mechanical performance of bio-based coating, which makes it highly suitable for paper and molded fiber packaging applications.