From plant to protection: waterproof and oil-resistant paper tableware made from pure plant material

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Disposable tableware is widely used in gatherings and take-out scenarios. As concerns over white pollution grow, paper tableware is increasingly replacing plastic alternatives. However, to achieve waterproof performance, paper tableware is often coated with a plastic film, which diminishes its degradability. To impart oil-repellent properties, per- and polyfluoroalkyl substances (PFAS) are frequently employed for molded fiber tableware. These compounds not only resist degradation but also pose significant environmental and health risks, accumulating in wildlife vegetation and potentially entering the human body through ecological pathways. Therefore, developing a safe and environmentally sustainable oil-resistant material is a critical imperative.

Inspired by the natural water and oil resistance observed in plants, we have synthesized a seamless and robust lignin film by applying nanolignin to the surface of substrate paper. In our study, commercial printing paper was coated with a molten lignin layer under hot press conditions. We examined the impact of various processing parameters on the quality of lignin films, testing four sets of conditions: film weight (10 to 40 g/m²), hot pressing pressure (1 to 5 MPa), hot pressing temperature (120 to 180 °C), and initial moisture content of suspension (10% to 50%) prior to hot pressing. Our results indicate that the optimal combination for producing high-quality lignin films with excellent waterproof and oil-proof properties includes a coating weight of 40 g/m², a hot-pressing pressure of 3 MPa, a hot-pressing temperature of 160°C, and a moisture content of 30%. Under these conditions, the lignin layer demonstrated remarkable waterproofing, maintaining its integrity for 100 minutes, and exhibited excellent oil resistance, lasting for 30 minutes.

To obtain a product without dark color, the nanolignin, PVA, and PLA copolymer were applied to the middle of two pieces of paper. As a result, a paper bowl with a clean appearance was produced with the help of a metal mold. The composite material achieved complete degradation within 56 days when buried in garden soil. This paper composite featuring a lignin film is inherently biodegradable and sustainable. This innovation presents a promising alternative to non-biodegradable plastics and PFAS, potentially revolutionizing the disposable tableware industry.