

## **From PFAS Dependency to Green Innovation: Delivering PFAS-Free Oven Paper for a Fortune 500 QSR Chain**

In today's market, where consumer safety and environmental stewardship are paramount, the pressure to eliminate per- and polyfluoroalkyl substances (PFAS) from food-contact products has never been greater. For decades, PFAS-based coatings have provided the ultra-low surface energy essential for superior grease resistance and thermal stability in oven paper—a critical component in the fast-paced kitchens of Fortune 500 quick service restaurant chains. However, increasing regulatory scrutiny and growing consumer demand for safer, greener alternatives compelled a leading paper mill to re-engineer its coating technology, embarking on a transformative journey toward PFAS-free production.

Our client was tasked with developing an alternative coating that could match, or exceed, the performance of traditional PFAS-based systems while ensuring full compliance with stringent food-contact safety standards. The challenge was significant: the new coating had to offer exceptional grease resistance and endure temperatures above 220°C, all without relying on the environmentally persistent PFAS compounds. In response, we assembled a multidisciplinary team of material scientists, chemists, and process engineers to develop a cutting-edge, sustainable solution based on the latest advances in material science.

We initiated the project by conducting an exhaustive review of the scientific literature and material databases. Our research highlighted several promising candidates, among which a multi-layer system combining a bio-based wax with a silicone-based resin emerged as the most viable pathway. We selected a high-melting-point bio-based wax, such as carnauba wax, renowned for its natural hydrophobicity and crystalline structure. Carnauba wax, composed predominantly of long-chain esters, fatty acids, and hydrocarbons, inherently provides a low surface energy—a critical factor in achieving superior grease resistance. To complement the wax, we integrated a silicone resin characterized by its robust Si–O–Si backbone, which imparts exceptional thermal stability and flexibility. The silicone resin, with its pendant methyl groups and crosslinked network, ensured that the resulting film could withstand repeated thermal cycling without degradation.

Armed with these materials, we formulated a series of emulsions, varying the silicone-to-wax ratio from 20:80 to 80:20 by weight. Each formulation was prepared using a food-grade non-ionic surfactant to ensure stability and compatibility with food-contact applications. Using precision roll coating techniques, we applied thin, uniform films—targeted at 1–2 g/m<sup>2</sup>—onto test substrates, setting the stage for a rigorous evaluation of their performance.

In our state-of-the-art laboratory, we subjected the coatings to a battery of advanced analytical techniques to confirm their efficacy. We began with water contact angle measurements, achieving values exceeding 120°—a clear indicator of the ultra-low surface energy required for effective grease resistance. Differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) were then used to characterize the thermal properties of the formulations. DSC revealed an endothermic melting peak corresponding to the carnauba wax component, while TGA confirmed that the coating maintained its integrity up to temperatures well above 230°C. Fourier-transform

infrared spectroscopy (FTIR) provided further validation: we observed strong Si–O–Si stretching vibrations near  $1080\text{ cm}^{-1}$  and carbonyl absorption peaks around  $1730\text{ cm}^{-1}$ , confirming the successful integration of the silicone resin and wax. Dynamic mechanical analysis (DMA) verified that the coating exhibited a stable storage modulus across the operational temperature range, ensuring that the film retained its adhesion and mechanical stability under stress. Additionally, scanning electron microscopy (SEM) and atomic force microscopy (AFM) revealed a defect-free, homogeneous film at the micro- and nanoscale—a critical factor in ensuring long-term barrier performance.

Having identified the optimal formulation in the laboratory, we turned our attention to process integration and scale-up. The new PFAS-free coating was incorporated into the paper mill's existing roll-to-roll production line. We employed near-infrared (NIR) spectroscopy as an in-line monitoring tool to ensure uniform coating weight and to verify that the chemical composition of the film remained consistent throughout production. Process parameters such as coating weight, drying temperature, and web speed were meticulously optimized to achieve a defect-free application at high production volumes. This rigorous process control was essential to translating our lab-scale success into reliable, large-scale manufacturing.

Given the intended use of the oven paper for food-contact applications, extensive regulatory and safety validations were imperative. Migration studies were conducted using gas chromatography–mass spectrometry (GC-MS) to detect any volatile organic compounds (VOCs) or residual monomers that might migrate into food under high-temperature conditions. Independent laboratories confirmed that the new PFAS-free coating met all FDA and European Union standards for food-contact materials, providing our client with the assurance needed to secure adoption by the Fortune 500 QSR chain.

The successful transition to a PFAS-free coating not only eliminated the environmental and health concerns associated with PFAS compounds but also enhanced the paper mill's market position as a leader in sustainable innovation. For the QSR chain, the new oven paper delivered excellent grease resistance and maintained structural integrity under rigorous oven conditions—matching or even exceeding the performance of traditional PFAS-based products. This breakthrough paved the way for a future in which performance and sustainability coexist, setting a new standard in the food-contact materials industry.

Our work on this project stands as a testament to the power of advanced material science and precise process engineering in transforming legacy manufacturing practices. By leveraging bio-based and silicone chemistries, combined with state-of-the-art analytical and in-line process control techniques, we successfully redefined industry standards and helped our client meet the evolving demands of both regulators and consumers.

**Contact Wintermarch Group at [info@wintermarch.com](mailto:info@wintermarch.com) to discover how our expertise in material innovation and process optimization can drive measurable, sustainable success for your business.**