Novel Polymeric Technologies for Pulp and Paper Products

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ABSTRACT

NanoPaper LLC develops solutions for the paper industry by integrating self-assembly of polymers and nanoparticles into pulp and paper products. By using surface modification of polymeric and particle additives, superior properties can be achieved in existing technologies and completely new product categories can be created. Surface modification also increases interactions between additives and cellulose fibers to promote retention and make better use of materials for a more economically and environmentally friendly product. NanoPaper has developed technologies using these principles to create high bending stiffness laminates with reduced pulp, grease resistant coatings that eliminate fluorinated compounds, and pigments that more effectively interact with fibers to reduce waste in colored paper grades. Nanotechnology and surface modification are crucial in all of these technologies to produce enhanced eco-friendly and economical products for the pulp and paper industry.

Keywords: paper, packaging, pigments, grease coating, surface modification

1 HIGH BENDING STIFFNESS PAPERBOARD LAMINATES

High bending stiffness is desirable in many paper and paperboard applications. This property is often achieved by manufacturing dense, high caliper sheets or boards. In addition to consuming large amounts of pulp, such paperboards or sheets must be subsequently fluted and glued to prepare high stiffness laminates. There exists a need for a single-step process to yield laminates of high stiffness with reduced weight, using inexpensive materials. Moreover, traditional papermaking, whether to produce paper or paperboard, results in stresses on the environment due to energy and resource usage. We are attempting to address these issues by producing high bending stiffness laminates that are made with minimal use of pulp while using renewable materials to impart bending stiffness to the laminate.

Our process uses inexpensive expandable fillers and other expansion agents that react in situ during laminate manufacturing. The core imparts high bending stiffness to these specially engineered laminates. The density and pore size are easily tunable, leading to precise control over stiffness and cost. We have also demonstrated different structural compositions as seen in Figure 1. Furthermore the expandable fillers are surface modified to impart different surface properties such as hydrophobicity and oleophobicity to the paperboard. The structure also offers significant advantages in applications where sound damping and thermal insulation are required. Finally, certain grades of our laminates are made using materials approved for food contact. Initial results show a 2x improvement in weight by volume compared to commercially available paperboards of comparable stiffness.

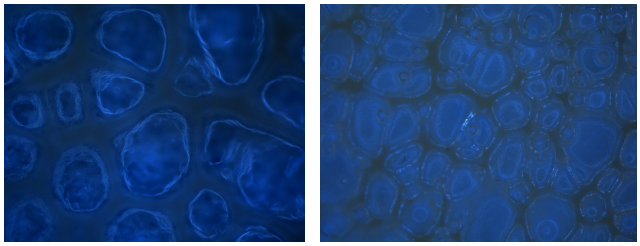

Figure 1: Images of expandable laminate core.

2 GREASE RESISTANT COATINGS

Grease resistant and oil-resistant coatings are used in a variety of applications including paper and board used in food packaging. Many of these treatments or coatings use fluorinated materials, and others use high amounts of polyolefins or other plastics. An alternative coating is needed to promote consumer safety in products as well as to reduce environmental impact. Our grease resistant coating has eliminated the need for these compounds. It is a durable thin coating that is resistant to folding and creasing while maintaining its oleophobic properties. The grease resistance can be seen in Figure 2 where a half-treated sample shows the coating's effectiveness as a barrier. Additionally, it performs well in a wide range of temperatures including the higher temperatures sometimes required in food packaging.

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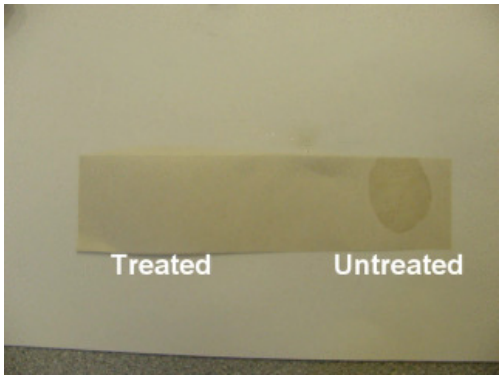

Figure 2: Grease resistance of paper both treated (left side) and untreated (right side) with grease resistant coating.

3 HIGH RETENTION PIGMENT COLORING SYSTEM

In producing colored paper, it is difficult to obtain consistent colors because small changes in dye concentrations significantly affect the end product. Also, dyes impart color to processing equipment requiring elaborate and time-consuming cleaning protocols. We have developed a high retention coloring system that can be surface modified to bond more effectively with the cellulose fibers. Common filler materials can be functionalized with dyes and encapsulated with special polymers to increase fiber interaction and retention. This allows for a decreased amount of waste in drainage waters as well as efficiency improvements in cleaning. Figure 3 shows the clear filtrate and improved retention from paper made with surface modified pigments as compared to the filtrate from paper made with traditional dyeing techniques.

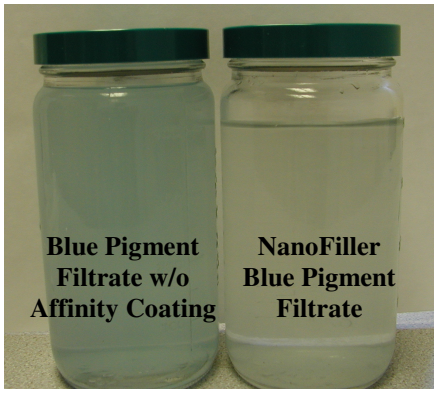

Figure 3: On the left is filtrate from traditional dyeing and on the right is filtrate from using surface modified pigments.

4 CONCLUSIONS AND FUTURE DIRECTIONS

NanoPaper LLC has exhibited use of surface modification and nanotechnology to solve problems in the pulp and paper industry. We have been able to apply these technologies in a wide range of applications. High-stiffness paperboard, grease resistant coatings, and high-retention coloring systems are a few examples of applications in which nanotechnology can be utilized in the pulp and paper industry. Ongoing experimentation is underway to give additional desirable properties to the traditional and novel products by means of surface modification.