Use of NANOSEAL™ Coatings to Create Clear, High-Barrier, Packaging Films

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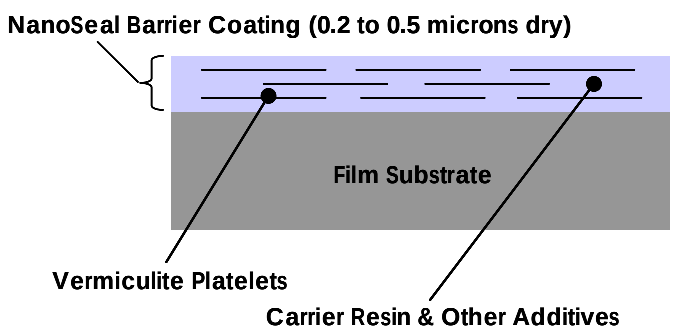
1. Summary

This document describes NanoSeal barrier coatings for packaging films and discusses the benefits (performance, economic and environmental) of using them in place of other optically-clear, barrier packaging materials.

2. Technology Overview

NanoSeal coatings are aqueous dispersions of vermiculite platelets in polyvinyl alcohol (PVOH). The platelets are 1-3 nanometers thick and 10-30 microns in breadth, yielding an average aspect ratio (breadth-to-thickness) of ~10,000:1. The platelets are maintained in singularized format when dispersed into the PVOH resin and aligned in the plane of the coating when deposited on a film substrate, such as polyethylene terephthalate (PET), biaxially oriented polypropylene (BOPP), biaxially oriented nylon (BON) or polylactic acid (PLA). The dispersed platelets create a tortuous path for gas molecules, enabling extraordinarily high gas barrier in a very thin layer (0.2 - 0.5 microns dry) with excellent bond strength, clarity and flexibility. The proprietary formulation also improves the moisture-resistance of the PVOH resin.



The key technical difference between NanoSeal coatings and past attempts to use nanoclays for barrier enhancement is that in NanoSeal coatings the clay platelets remain in singularized format not only when dispersed in the resin, but also during and after deposition on the film substrates. This achievement presents the tortuous path required for high gas barrier, while enabling the cohesive strength necessary for multi-layered packaging film structures.

NanoSeal coatings are applied to flexible films using standard printing and coating equipment (e.g. rotogravure and flexographic presses).

3. Applying NanoSeal Coatings

NanoSeal coatings are manufactured as a two-part system: (i) a masterbatch of carrier resin and additives, and (ii) a water slurry of vermiculite platelets. The two parts are mixed gently under ambient conditions just prior to applying the coating.

There are several important operating parameters to consider when applying NanoSeal coatings to a film substrate:

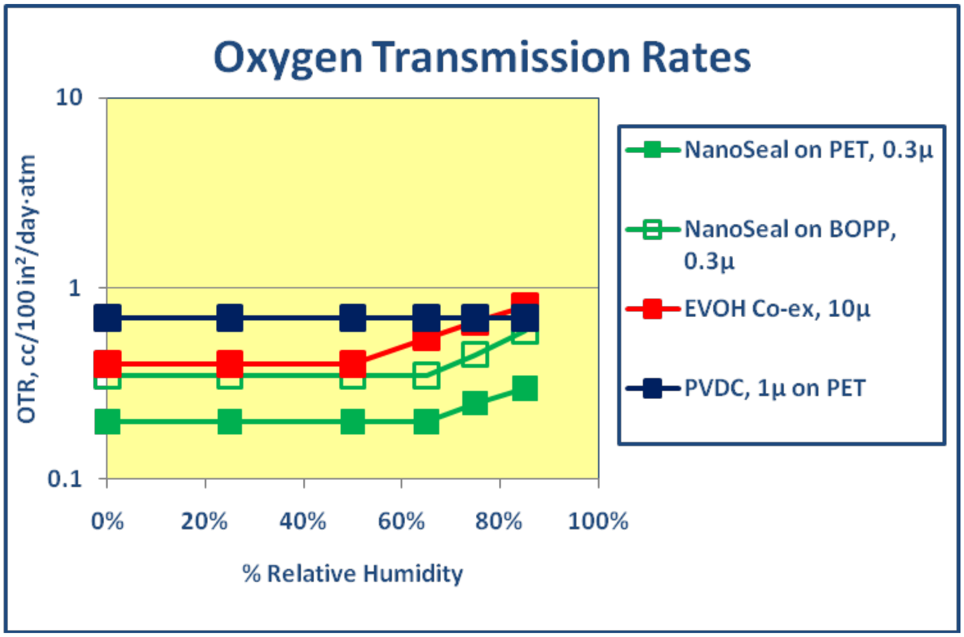
- For anchoring the coating on BOPP, a minimum surface energy of 43 dyne-cm is recommended. For PET, BON and PLA, a primer is required for good wet-out on the films and good bond strength.
- Anilox roller design requires that lines per inch (lpi) not exceed 200; cell layout design is not limited: quad, 30º, 60º, open and closed channel have all proven effective.
- A smoothing bar is required when using direct gravure, to align the platelets in the plane of the coatng. Reverse gravure and flexographic applications do not require a smoothing bar.
- NanoSeal coatings have very low solids content (<10%), so adequate drying capacity is required.
- The heat from drying ovens initiates PVOH cross-linking. Curing, and resultant bond strengths, will continue to improve for up to 7 days.
- Because the coating does not heat seal to itself, a sealant layer is required (e.g. polyethylene, polypropylene, etc.), Sealant films can be adhesive laminated directly to the NanoSeal coating, using solvent-based, solventless or water-based adhesive systems.
- A polyethylene sealant film can be extrusion coated onto the NanoSeal coating, using a primer to affect good bonding.
- Solvent-based inks based on nitrocellulose or polyurethanes can be used; water-based inks have also been used.

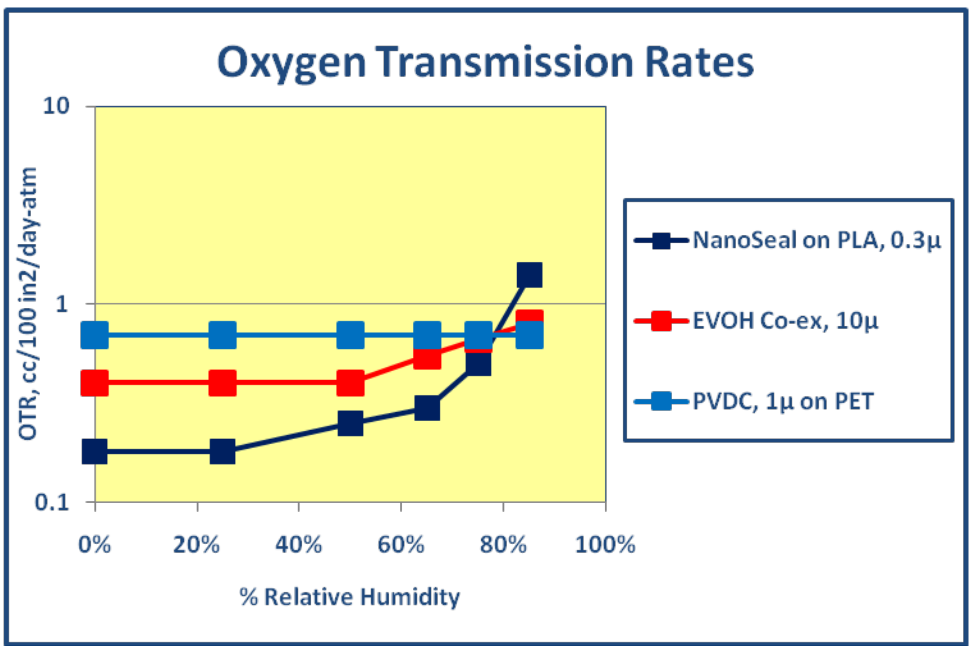
4. Advantages of NanoSeal coatings

Performance. NanoSeal coatings deliver significantly better gas barrier compared to competing clear barrier materials, such as polyvinylidene chloride (PVdC) and ethylene vinyl alcohol (EVOH).

Additionally, NanoSeal is not corrosive like PVdC (contains chlorine), has better moisture resistance than EVOH, and is not prone to flex-cracking like AlOx or SiOx.

NanoSeal coatings can be formulated with different loadings of vermiculite or applied at different thicknesses, to enable different levels of gas barrier, depending on the requirements of a given packaging application.





Cost savings. In general, NanoSeal coatings yield package structures that are 10-50% less expensive than traditional package structures of comparable barrier performance. Future NanoSeal products will enable even more significant cost reductions by incorporating platelets into other materials (e.g. adhesives, primers, sealant coatings, etc.), thus eliminating entire package layers.

Environmental benefits. NanoSeal coatings address a number of environmental concerns commonly associated with barrier materials. First, they enable significantly better gas barrier than alternatives while using 60-95% less material (reducing the amount of packaging material is the US EPA's top objective in addressing landfill issues). Second, NanoSeal coatings displace PVdC, which contains free chlorine, which has been increasingly targeted for elimination because of its processing and disposal hazards. Third, scrap packaging coated with NanoSeal coatings can be re-ground and blended into virgin resin for re-use, unlike some barrier materials. And finally, NanoSeal coatings dissolve in landfills, and do not inhibit the bio-degradability of compostable packaging.