SURFACE TREATMENT

The surface energy of a packaging film, often times referred to as the “dyne” level (dynes/cm) is a critical film property when printing, coating or laminating packaging films. The main objective of any surface treatment method is to increase the surface energy of the film surface to improve wet-out and adhesion of coatings, inks and adhesives used in converting the film into packaging. Typical polymers used for packaging films will naturally have a surface energy without surface treatment anywhere from 29 to 45 dynes/cm. A typical rule of thumb to insure good wet-out and adhesion to a substrate is that the surface energy of the substrate should be 7-10 dynes/cm higher than the surface tension of the coating being applied. As an example water has a surface tension of 72 dynes/cm compared to the surface tension of methanol which is 22.6 dynes/cm. The surface energy of a polyester film is approximately 42 dynes/cm thus allowing the methanol to easily wet-out the surface of the polyester, however the water (~72 dynes/cm) which is 50 dynes higher than the methanol will bead up, not wetting out the polyester film.

There are several different ways of surface treating a film to increase the surface energy thus improving wet-out and adhesion of various coatings, inks and adhesives. Corona discharge, flame treatment, priming and chemical etching can be used, typically individually, to increase the surface energy of a packaging film. These treatment methods can be effective if used correctly.

Priming

Priming film to increase surface energy and improve adhesion of a coating, ink or adhesive often times is done in conjunction with corona treatment. The film is corona treated to increase the surface energy enough to provide good adhesion for the primer coating to the film. A primer is selected that will provide a high surface energy for good adhesion and possibly improve the surface texture of the film. This method can increase the cost of the film greatly.

Chemical Treatment

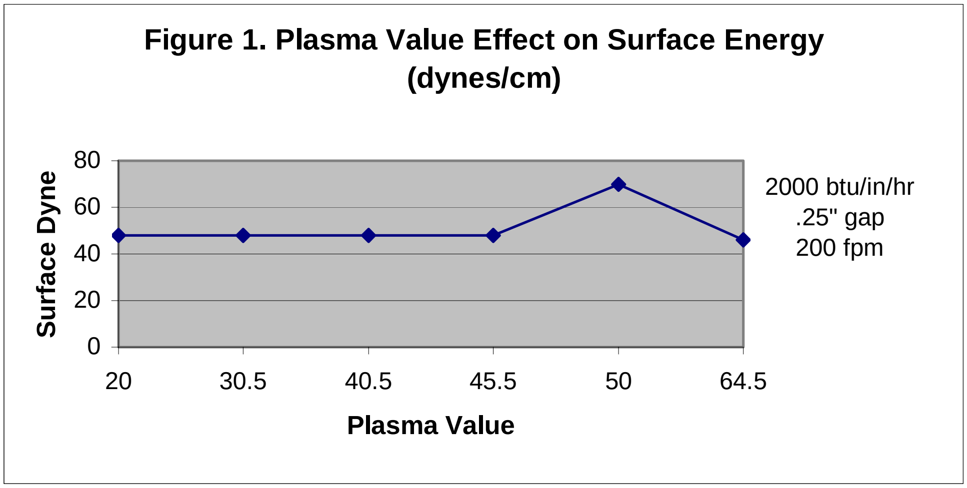
Chemical treatment of a film typically involves cleaning, etching and rinsing steps. The cleaning removes any surface contaminants. The etching involves the use of an acid, base or oxidizing agents such as nitric acid (NHO_3) or potassium chromate ($K_2Cr_2O_7$) to chemically change the polymer surface[i]. Finally the film is rinsed clean of the etching chemicals and dried. This process is usually done following film manufacturing, which significantly adds to the final cost of the film. This treatment method is often slow and creates waste disposal issues.

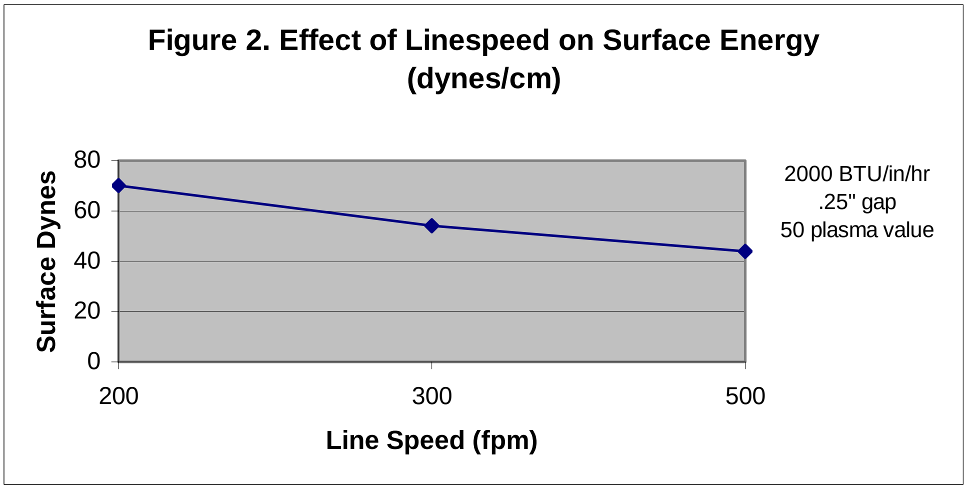
Flame Treatment

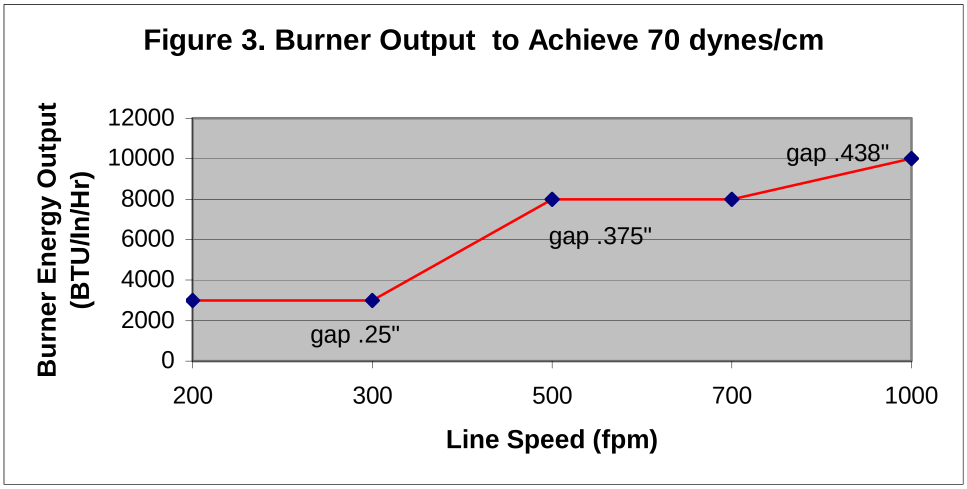
Flame treatment involves the use of a burner unit that generates a flame with a specific plasma value (PV) ratio or fuel to oxygen ratio. The film passes directly through the flame tips, which have formed oxygen rich plasma thus treating the surface of the film in contact with the flame. This treatment method is said to produce high surface energy levels and longer lasting treatment levels. In the past this method was considered dangerous due to the presence a long open flame. However, improvements in equipment design and controls have greatly reduced the hazards.

A flame treatment study was conducted on biaxially oriented polylactide (BOPLA) film to evaluate the maximum obtainable increase in surface energy and the length that the film can retain the increased surface energy. A BOPLA film that had not been previously corona or flame treated was tested for the effect of burner gap, plasma value (PV), line speed and burner output to determine the best settings to obtain the maximum increase in surface energy. In addition, samples of flame treated BOPLA film were stored and tested over time to determine how long the film will hold the high surface energy level.

Figure 1 shows that a plasma value of 50 obtains the highest surface energy level (>70 dynes/cm) for BOPLA film. A plasma value of 50 is considered to be a 1:1 ratio of fuel to oxygen and a 10-point shift in this value represents a 1% change in the fuel to oxygen ratio. As an example a plasma value of 40 signifies a fuel to oxygen ratio that has a 1% excess of oxygen. Most packaging films used for flexible packaging achieve the highest surface energy when flame treated with a plasma value of 45, representing 0.5% excess oxygen in the fuel mixture. Figure 2 shows that when the line speed increases, the surface energy drops when using a fixed burner output and burner gap. This indicates that the burner output must increase as the line speed increases to maintain a high surface energy and subsequently the burner gap must be increased to prevent the film from distorting from the heat of the flame. Figure 3 shows the relationship between line speed and burner output to maintain a surface energy of greater than 70 dynes/cm on BOPLA film.







Corona Treatment

Corona treatment consists of a high voltage electrical discharge across a fixed air gap between an electrode and a dielectric, usually a roller for web treatment applications. This discharge forms a corona in the gap between the electrode and the dielectric roller, thus treating the film surface toward the electrode. Treatment typically will decay over time and is adversely effected by high humidity conditions. Corona treatment is often done during film manufacturing and can be done again in-line with a secondary converting process such as printing to "bump" the film surface energy. This treatment method is user friendly can be run at high line speeds (in excess of 1000 feet per minute) and can be controlled by the line speed to control the final treatment level.

A corona treatment study was conducted on BOPLA film to evaluate the obtainable increase in surface energy and the length that the film can retain the surface energy increase. BOPLA film that was corona treated during manufacturing and BOPLA film that had no previous treatment were evaluated for discharge energy (watt density watts/square area) verses obtained surface energy and the length of time in days that the film retained the surface energy. Figure 4 shows that very little watt density (1.0 watt density using a "universal roller") needs to be applied to the treated BOPLA to effectively "bump" treat the film to a surface energy of 48 dynes or higher. Unlike PP film, BOPLA that has not been corona treated during film manufacturing can be corona treated effectively at a later date. Figure 5 shows untreated BOPLA film does require more watt density to effectively increase the surface energy when compared to "bump" treatment, but not an unreasonable amount of watt density to be effective.

Figure 4.
Initial Corona Treatment of BOPLA Film
Surface Energy Decay Study

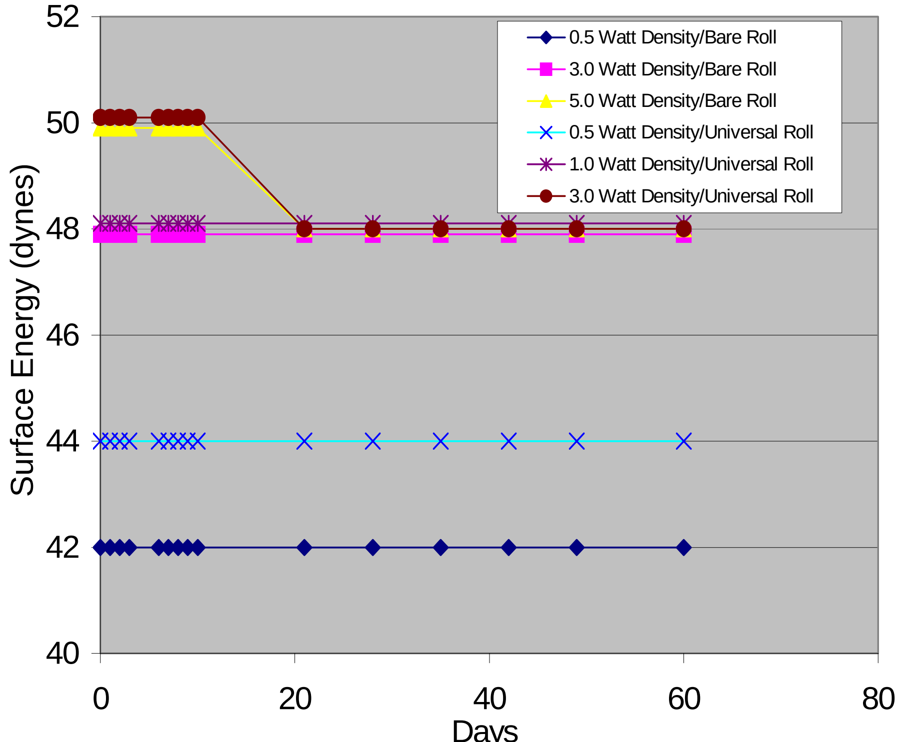
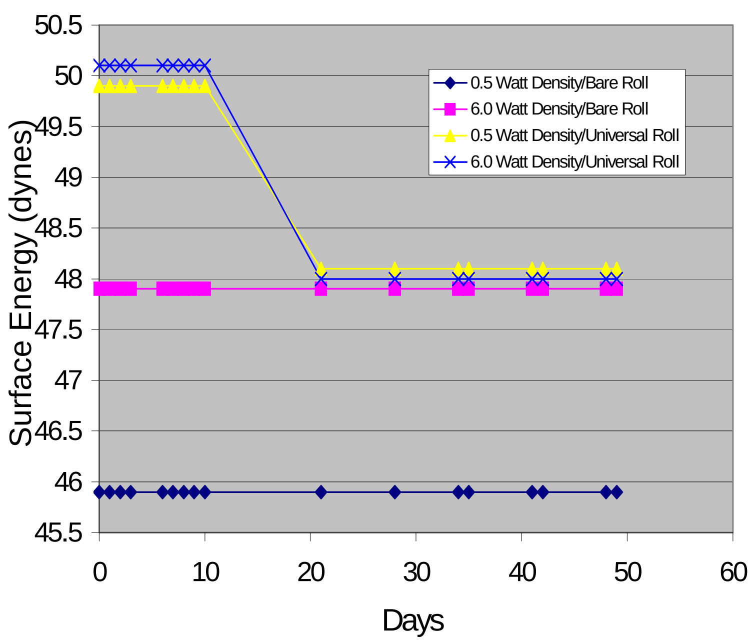


Figure 5.
"Bump" Corona Treatment of BOPLA Film
Surface Energy Decay Study



Safety and Handling Considerations
Material Safety Data (MSD) sheets for PLA polymers are available from NatureWorks LLC. MSD sheets are provided to help customers satisfy their own handling, safety, and disposal needs, and those that may be required by locally applicable health and safety regulations, such as OSHA (U.S.A.), MAK (Germany), or WHMIS (Canada). MSD sheets are updated regularly; therefore, please request and review the most current MSD sheets before handling or using any product.

The following comments apply only to PLA polymers; additives and processing aids used in fabrication and other materials used in finishing steps have their own safe-use profile and must be investigated separately.

Hazards and Handling Precautions
PLA polymers have a very low degree of toxicity and, under normal conditions of use, should pose no unusual problems from incidental ingestion, or eye and skin contact. However, caution is advised when handling, storing, using, or disposing of these resins, and good housekeeping and controlling of dusts are necessary for safe handling of product. Workers should be protected from the possibility of contact with molten resin during fabrication. Handling and fabrication of resins can result in the generation of vapors and dusts that may cause irritation to eyes and the upper respiratory tract. In dusty atmospheres, use an approved dust respirator. Pellets or beads may present a slipping hazard. Good general ventilation of the polymer processing area is recommended. At temperatures exceeding the polymer melt temperature (typically 170ºC), polymer can release fumes, which may contain fragments of the polymer, creating a potential to irritate eyes and mucous membranes. Good general ventilation should be sufficient for most conditions. Local exhaust ventilation is recommended for melt operations. Use safety glasses if there is a potential for exposure to particles which could cause mechanical injury to the eye. If vapor exposure causes eye discomfort, use a full-face respirator. No other precautions other than clean, body-covering clothing should be needed for handling PLA polymers. Use gloves with insulation for thermal protection when exposure to the melt is localized.

Combustibility
PLA polymers will burn. Clear to white smoke is produced when product burns. Toxic fumes are released under conditions of incomplete combustion. Do not permit dust to accumulate. Dust layers can be ignited by spontaneous combustion or other ignition sources. When suspended in air, dust can pose an explosion hazard. Firefighters should wear positive-pressure, self-contained breathing apparatuses and full protective equipment. Water or water fog is the preferred extinguishing medium. Foam, alcohol-resistant foam, carbon dioxide or dry chemicals may also be used. Soak thoroughly with water to cool and prevent re-ignition.

Disposal
DO NOT DUMP INTO ANY SEWERS, ON THE GROUND, OR INTO ANY BODY OF WATER. For unused or uncontaminated material, the preferred options include recycling into the process or sending to an industrial composting facility, if available; otherwise, send to an incinerator or other thermal destruction device. For used or contaminated material, the disposal options remain the same, although additional evaluation is required. (For example, in the U.S.A., see 40 CFR, Part 261, “Identification and Listing of Hazardous Waste.”) All disposal methods must be in compliance with Federal, State/Provincial, and local laws and regulations.

Environmental Concerns
Generally speaking, lost pellets are not a problem in the environment except under unusual circumstances when they enter the marine environment. They are benign in terms of their physical environmental impact, but if ingested by waterfowl or aquatic life, they may mechanically cause adverse effects. Spills should be minimized, and they should be cleaned up when they happen. Plastics should not be discarded into the ocean or any other body of water.

Product Stewardship
NatureWorks LLC has a fundamental duty to all those that make and use our products, and for the environment in which we live. This duty is the basis for our Product Stewardship philosophy, by which we assess the health and environmental information on our products and their intended use, then take appropriate steps to protect the environment and the health of our employees and the public.

Customer Notice
NatureWorks LLC encourages its customers and potential users of its products to review their applications for such products from the standpoint of human health and environmental quality. To help ensure our products are not used in ways for which they were not intended or tested, our personnel will assist customers in dealing with ecological and product safety considerations. Your sales representative can arrange the proper contacts. NatureWorks LLC literature, including Material Safety Data sheets, should be consulted prior to the use of the company’s products. These are available from your NatureWorks LLC representative.

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