



Energetic Surface Treatments

Advanced methods increase surface energy and properties.

By Michael Tolinski

Additional processing steps are sometimes required for enhancing a material's surface properties. For example, nonpolar materials such as polyolefins have low surface energy and reactivity, which means they may require surface treatments to adhere to inks and coatings. Promoting adhesion is made even more challenging with the use of water-based coatings, which have higher surface tension than solvent coatings and thus even less tendency to wet out on a polymer surface.

Fortunately, technologies are improving for applying corona, flame, and plasma surface treatments—the most-used alternatives to chemical treatments for promoting adhesion and wettability. Meanwhile, the advantages of a more specialized surface treatment—electron beams—are becoming more compelling.

Corona Configurations

One way of increasing surface energy and reactivity is to bombard the polymer surface with ions. Along with flame treatment, which delivers reactive ions via a burning gas jet, corona surface treatment has become the most common method. Typically used for treating thin webs, corona systems can also be used for treating extruded profiles and pipe. “It is now possible to treat multiple surfaces and difficult configurations with superior one-pass coverage,” says Luise Bang of Denmark-based Tantec (U.S. office in Glendale Heights, Illinois, USA).

Tantec offers in-line corona systems for extruded profiles. These are composed of three to five treatment heads for handling high line speeds (up to 20–25 m/min, depending on the profile). The company's ProfileTec system, for example, reportedly has been used to increase the surface energy of extruded EPDM rubber from 34 to 50 milli-Newtons/meter, “which is the tension level required for the best adhesion possible,” says Bang. The resulting EPDM profiles are used for weatherstrips and automotive seals.

Polyolefin piping for gas and water likewise benefit from corona treatments, Bang adds. PE and PP piping

resists chemicals well, but it has poor wettability and adhesion; thus it's difficult to print critical identifying information on the outer surface of the pipe or to bond insulation to the inner surface.

So Tantec developed corona systems that treat both the outside and inside of pipes. SpotTec in-line treatment systems are designed increase surface energy just enough for the labeling ink to stick to the outer wall. For the inner walls of heating pipes, PipeTec systems help ensure that hard polyurethane foam insulation will bond inside the pipe. Typically used inside large extruded pipes at slow line speeds (0.5–10 m/min), this system is usually installed between the extruder and the saw that cuts the pipe into 6-m sections.

Atmospheric Plasma

For treating complex surfaces, plasma surface treatment is often the chosen approach. Plasma is said to offer more stable, more uniform, and longer-lasting surface energy enhancement than corona, using a similar-sounding concept. Basically, plasma systems ionize a gas mixture in an electromagnetic field; the ionized gas is discharged against the polymer, increasing chemical functional groups and wettability on the surface.

However, traditional plasma systems must operate at low pressures, a constraint that is motivating the development of atmospheric-pressure systems. “Atmospheric-pressure plasmas provide a critical advantage over widely used low-pressure plasmas, as

they do not require expensive and complicated vacuum systems,” reports Rory Wolf, VP and product manager for Enercon Industries Corp. (Menomonee Falls, Wisconsin, USA).

In recent years, atmospheric plasma has been used in roll-to-roll converter operations at commercial speeds. Lately, Enercon has developed its “Plasma3” system to improve adhesion on more nontraditional rolled materials. The system reportedly improves photoelectric digital-printer ink adhesion on DuPont’s Tyvek, a nonwoven sheet material composed of very fine polyethylene fibers heat-bonded together.

However, atmospheric plasma alone doesn’t increase surface energy permanently. Wolf says the effects can be extended by a secondary chemical treatment that further activates a plasma-treated surface. In this photografting process, a chemical is grafted to the polymer using UV light, permanently locking in a higher surface energy. The process has been commercialized under the name “Prime IT” by Ciba Specialty Chemicals (Tarrytown, New York, USA).

Enercon also has developed “variable chemistry plasma” (VCP) processes for difficult-to-treat 3-D applications, like PC/ABS cellphone jackets. Without chemical priming, etching, or vacuum processes, VCP manipulates the composition of the plasma gas itself to deposit the desired chemical groups on the substrate surface. The resulting surface characteristics depend on which gas chemistry is employed.

E-Beam X-Linking

Electron-beam (e-beam) irradiation may be better known for its use in sterilizing medical products, but its abilities to crosslink and toughen polymer surfaces are becoming clearer, according to researchers from E-Beam Services, Inc. (Cranbury, New Jersey, and Lebanon, Ohio, USA). At ANTECT™ 2007, they highlighted case studies on the use of e-beam treatment in crosslinking typical

polyethylene products, compared with traditional methods. For instance, chemically crosslinked PE (PEX) tubing has been used for decades to meet ASTM requirements for thermal stability under load and environmental stress cracking resistance (ESCR). But chemical crosslinking with peroxide and silane agents presents some disadvantages that e-beam treatment avoids.


E-Beam Services compared chemical and e-beam methods for crosslinking 16-mm extruded pipe. The researchers found that radiation-crosslinked PE has equal or better burst-test performance, “particularly at the highest temperature” tested (93.3°C). Along with this result, they note that the nonradioactive e-beams are environmentally cleaner and safer than chemical crosslinkers. The process also has fewer process variables to control, making results more consistent. And e-beam PEX tubing scrap can be recycled.

“Peroxide and silane crosslinked PEX cannot be recycled after extrusion, leading to higher scrap rates and the associated disposal fees.”

Of interest to rotomolders is the case of LLDPE gas tanks. Here, e-beam crosslinking enhanced the key properties of low-temperature impact and ESCR. To determine the effects of various levels of irradiation, the researchers exposed roto-

molded tanks to different e-beam treatments and tested them at -40°C and in Igepal solution. Improvements in low-temperature impact resistance corresponded with the e-beam dosage level (although double the dose did not double the impact failure energy). In the ESCR testing, e-beam samples showed no failure after 1000 hours of chemical exposure, unlike the control samples, which failed at 85–500 hours.

“These improved properties can allow for a greater range of uses for rotomolded polyethylene parts,” the researchers conclude. We might also look to a future when industrial e-beam equipment is more affordable; right now, contract service companies remain the most cost-effective option for e-beam processing.



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