Direct electrostatic coating of paper

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SUMMARY: Direct Electrostatic Coating (DEC) of paper uses "as polymerized" reactor polyolefin and an electrostatic spraying applicator. A glossy/transparent polymer coat was obtained after hot-pressing the electrostatically deposited powder layer on the paper surface. Paper coated using powders such as polypropylene and biopolyesters (poly-P-hydroxyalkanoates) showed good barrier properties and remarkable adhesion between the polymer film and the fibrous texture. Dry blends of polyolefin powder and common inorganic fillers (e.g., clay, $CaCO_3$) up to 40% (wlw) provided powder formulations suitable for electrostatic coating. DEC is environmentally friendly and potentially of low cost while being simple, flexible and adaptable to the end-use paper requirements.

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Electrostatic coating offers opportunities to meet today's environmental requirements (Azzam 1973). In this process, a fine dispersion of coating material is electrically charged (positively or negatively) and directed toward the charged substrate (opposite electrical sign). The electrostatic attraction between the charged particles and oppositely charged substrate controls the deposition and layering of the materials in the coating. Numerous applications of electrostatic coating, often involving elegant technology, have been described (Miller 1973).

Early applications employing electrostatic forces for coating fibrous substrates (e.g. paper and paper-related materials) are found in sandpaper manufacture (Melton et al. 1940) and in the flock coating process (Amstuz 1941). First mention of an electrostatic process for coating paper using dry polymer powders dates to 1955 (Reif 1955). The process was developed for the Bergstrom Paper Co., Neenah, Wis., in work sponsored at Battelle Memorial Institute, Columbus, Ohio. An outcome of this development was reported in 1961 as the commercial application for the production of a gummed web material (Holt et al. 1961). These electrostatics-based processes depended on complex equipment and expensive coating materials to meet the requirements of the process. Today it is the cost of the powder materials which limits development toward large scale application in the paper field.

An interesting use of electrostatic coating in the reprographic industry has been labeled "Direct Electrostatic Printing" (Schmidlin et al. 1990). It is a simple, inexpensive computer controlled means of creating images on paper directly from digital information. It involves direct projection of toner onto paper for temporary displays and may or may not involve fusing.

Although paper coating is based on a wide variety of technologies, wet-coating remains the "backbone" of the industry (Booth 1970). Generally, wet-coating creates an optimized layer at the surface of the sheet that smooths the contours of the pore-fibre interface. For certain speciality papers solvent coating is also used. To meet barrier requirements (e.g. moisture, O_2 barrier) laminating a pre-extruded hot polymer film onto the paper substrate has become an important paper technology. The solventless aspect of this approach is an attractive environmental feature. However, pre-extruded melt-coating does not allow formulation flexibility, as in wet-coating applications, and is energetically expensive.

This paper presents the results of our work in developing a solvent-free coating process for fibrous substrates (e.g. paper, non-wovens and the like) based on electrostatics. Our main objective is the use of inexpensive polymer powder for coating the substrate in a simple, direct process. The outcome will be a thin layer of polymer powder on the substrate which is subsequently fused and calendered to give a uniform coating. The final product will be an optimally designed coated paper with improved properties thanks to the formulation potential of blended powders to provide adhesion, opacity, porosity, wetting and sorption at the surface.

Materials and process

Three major elements retained our attention:

- source(s) of inexpensive polymer powder with thermoplastic characteristics corresponding to our purpose;

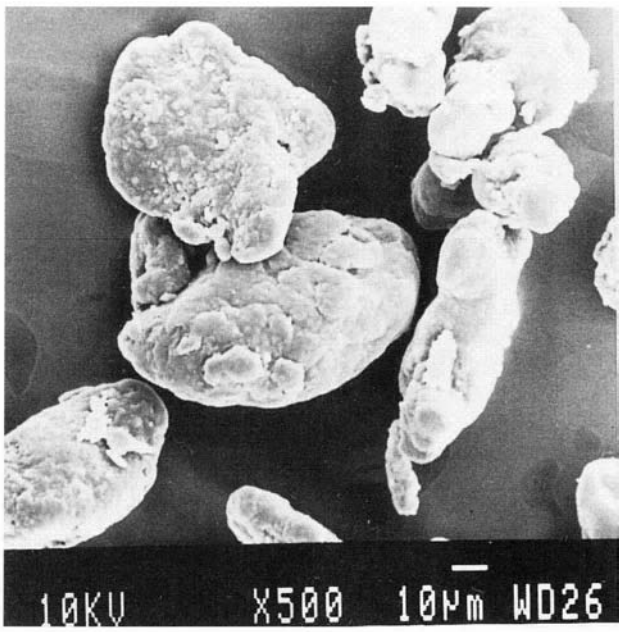

Fig. 1. Scanning electron micrograph of "as received" polypropylene powder (Himont) used for DEC experiments.