EB for Active Coatings

By George Sadler

PROVE IT (Packaging Regulation, Optimization, Validation and Education for Innovative Technologies) emerged in 2006 from the author's 20-year academic experience in food chemistry, food packaging and FDA regulatory indirect food additive submission experience. Its startup was funded through the United States Department of Agriculture (USDA) and the National Aeronautics and Space Administration (NASA) Small Business Innovation Research (SBIR) Program grants for active packaging, novel packaging concepts, and alternative food processing technologies. PROVE IT has strong collaborative ties with Purdue University (NASA projects) and Pilot Aseptics (food processing technologies). The company seeks to set the direction for food processing and packaging for the 21st Century.

PROVE IT, LLC, in collaboration with Purdue University, is exploring various low energy (≤ 150 keV) electron beam (EB) treatments for various food and pharmaceutical packaging related applications. Some of these applications include:

Active Packaging

The PROVE IT/Purdue approach for package activation "prints" activities onto the surface of polymers which are then instantaneously set in e-beam curable resins. Printing technologies include flexographic, ink jet, offset, lithographic and other mature printing technologies. Since insignificant heat is produced during the curing process, plastic surfaces can be activated with thermolabile biological materials. Since existing printing technology is used, activities can usually be applied for less than one cent per container. Some of the applications being explored include:

Glucose Oxidase Oxygen Removal Systems

Glucose oxidase—either alone or in conjunction with other enzymes—removes oxygen from systems composed of sugars and polysaccharides containing glucose or other sugars which can be enzymatically converted to glucose. The enzyme(s) can be ink-jet printed in e-beam curable resins onto inner bottle closure surfaces (or otherwise printed on food-contact packaging surfaces) and then be cured with EB to fix the activity in the resin with virtually no extraction of active components or resin constituents into the food. Oxygen removal is rapid and potentially lasts for many months.

Lactase Removal from Milk Consumed by Lactose Intolerant Populations

Similar to glucose oxidase, lactase has been successfully immobilized on packaging surfaces. When milk-containing lactose is filled into activated containers, the lactose undergoes rapid conversion to glucose and galactose. Both glucose and galactose are well tolerated in lactose-sensitive populations.

Bacteriophage

Bacteriophage are viruses which target bacteria with high species specificity. They are ineffective on eukaryotic organisms. The USDA has approved the use of a multivalent anti-lysterial bacteriophage to destroy *Lysteria monocytogenes* on cut beef surfaces. Both anti-lysterial and anti-*E. Coli* bacteriophage have been printed onto polymer surfaces with high retained activity. A Cobb-A modified reporter strain of *E. coli* is being developed

which produces a red color if *E. coli* is present. The strain will serve as a quick clinical screening test for *E. coli.*

Antimicrobial Agent

Bacteriocins such as nicins and lactoferrins can be bound in e-beam treated polymers designed to allow slow release of the materials to the polymer. The e-beam emitter will also be used to activate packages with non-thermally labile activities and features include:

A Percent-Shelf-Life-Remaining Graphic

This graphic indicates the fraction of shelf life remaining for a food. Unlike the current best-when-used-by-date system, the graphic tracks with temperature and potentially humidity, so the graphic advances faster for thermally abused foods versus properly stored food.

Chemical Oxygen Scavengers

The active materials in FDA-approved Multisorb and Monoxbar oxygen scavenger systems can be printed on inner closure surfaces or under EVA seal elements to remove oxygen in oxygen-sensitive glass and PET containers without the need for sachets or without melt incorporation of the active ingredient in the polymer.

Oxygen Status Indicators

These indicators respond to the oxygen partial pressure in a package and can be applied in e-beam curable resins.

Localized Silicon-Based Antifoam Material

This material is applied and e-beam fixed onto the inner finish of carbonated drink bottles. The antifoam controls overflow of carbonated drinks when containers are first opened.

Silver Zeolite

Silver zeolite is an FDA- and EPA-approved broad spectrum antimicrobial compound. The antimicrobial activity of surface-printed e-beam cured silver zeolite is well retained in e-beam cured resins.

Low-Energy EB Treatment for Microbial Control

The food industry has explored the use of electron beam treatment for sterilization of fitments

There is evidence that EB in the presence of hydrogen peroxide or para-acetic acid will force fulminating decomposition of these chemical compounds to produce a potently-antimicrobial storm of free radicals. Insignificant starting chemical remains. Therefore, vapor drying or water washing may be unnecessary while killing power is vastly increased over chemical application alone.

Exploring e-beam sterilization fundamentals

There is little public work to examine ideal electron energies and shadowing effects on bio-reduction. Sterilization with electrons of the lowest energy possible protects treated polymer surfaces. Also, lower energy streams favor many electrons with low-energy versus a few electrons with high energy. However, low energy streams may not be as suitable for shadow areas of the irradiated surface or may be more susceptible to blockage by dust or errant drops of products. Greater study and general publication of beam energy versus sterilization efficacy is currently under examination.

Low-energy e-beam treatment of food

Calculations show that a 150 keV emitter produces sufficient energy to sterilize liquid foods passing through flattened straws up to some critical channel size. Such treatments may have food and pharmaceutical applications.

Most of these processes have received at least some technical or theoretical treatment and some are well on their way to commercialization. New applications are being devised all the time. While some applications will require FDA review, the photoinitiator-free systems allowed by e-beam treatment will greatly facilitate regulatory approval. ◗

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About PROVE IT LLC

PROVE IT LLC is a collaborative effort of several renowned food scientists and engineers who have over 75 years of combined experience in the areas of safety, quality and regulation. The goal of this organization is to provide the industry and the alliances with guidance in the aforementioned areas, which is not only affordable but also customizable to unique needs and specialties (including GMPs, HACCP implementation, packaging and labeling regulations).

The goal of PROVE IT is to consult and help both small scale and large-scale food industries with their needs in the areas of food safety, quality and packaging regulation. Apart from consulting, one of the main focal points of PROVE IT is to innovate and invent cutting-edge technologies in the areas of food science and technologies. Some of the successful inventions are:

- The use of energy-curable material for the production of anti-microbial packaging [patent pending]
- Efficient heat-processing using magnetic induction [patent pending]
- Food and produce safety using electron beam irradiation.