



Activating surfaces with antimicrobial, chemical, and biochemical functionalities using energy-curable polymers

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PROVE IT, LLC

May 30, 2012



Our Research Interests

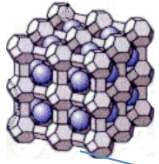


Novel Thermal Processes (Food and Pharma)

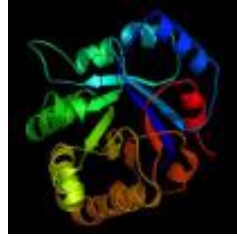
Novel Packaging and Printing

Regulatory Chemistry & FDA Submissions

Chemical



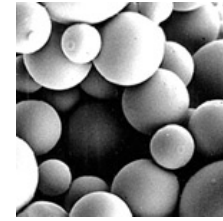
Biochemical



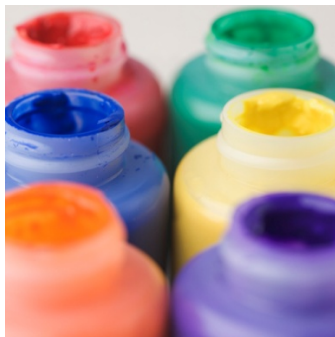
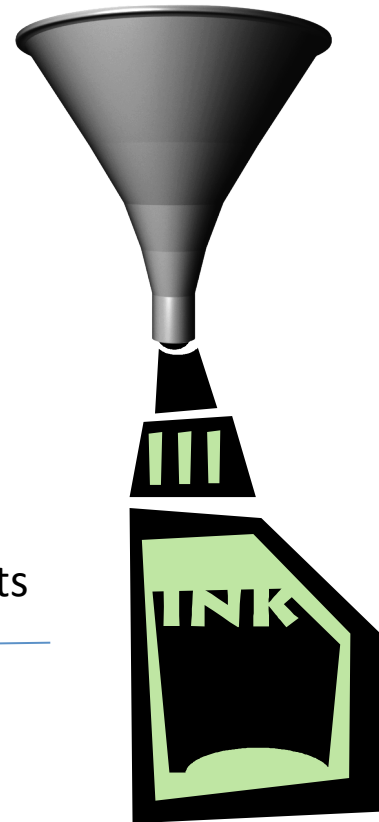
Biological



Micro Capsules



General Approach

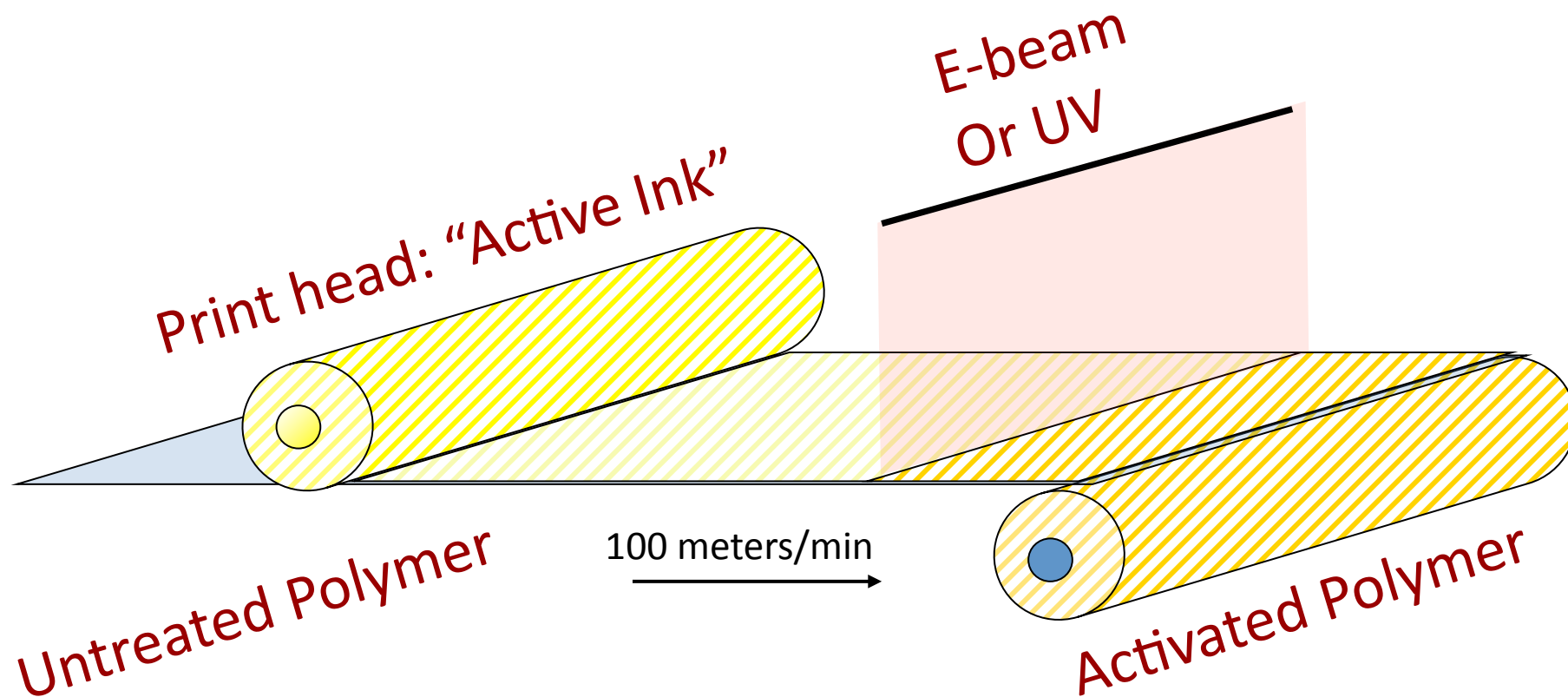


Remove Pigments

Energy Curable
Print Resins



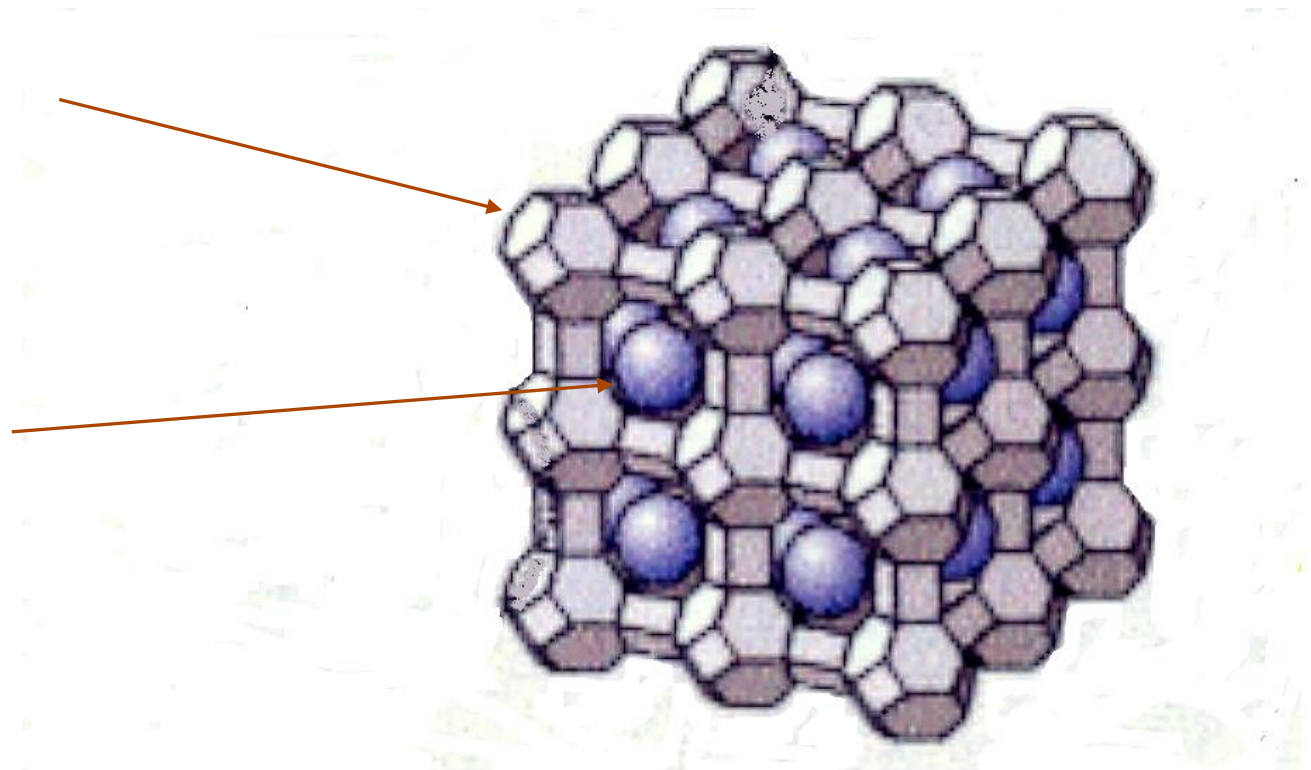
Active “Inks”



Silver Zeolite: Antimicrobial FDA, EPA

Zeolite
Matrix

Silver



Food Processing and Packaging

- Conveyor systems
- Cutting surfaces
- Packaging films and foils
- Refrigeration equipment

Medical Devices

- Catheters
- Luers
- Surgical Trays

Water Filtration and Delivery Systems

- Bottles
- Dispensers and coolers
- Filters
- Ice machines
- Tubing and connectors

Heating, Ventilation, Air Conditioning

- Air handlers
- Coils and fin stock
- Ductwork and vents
- Filtration media
- Refrigeration

Appliances

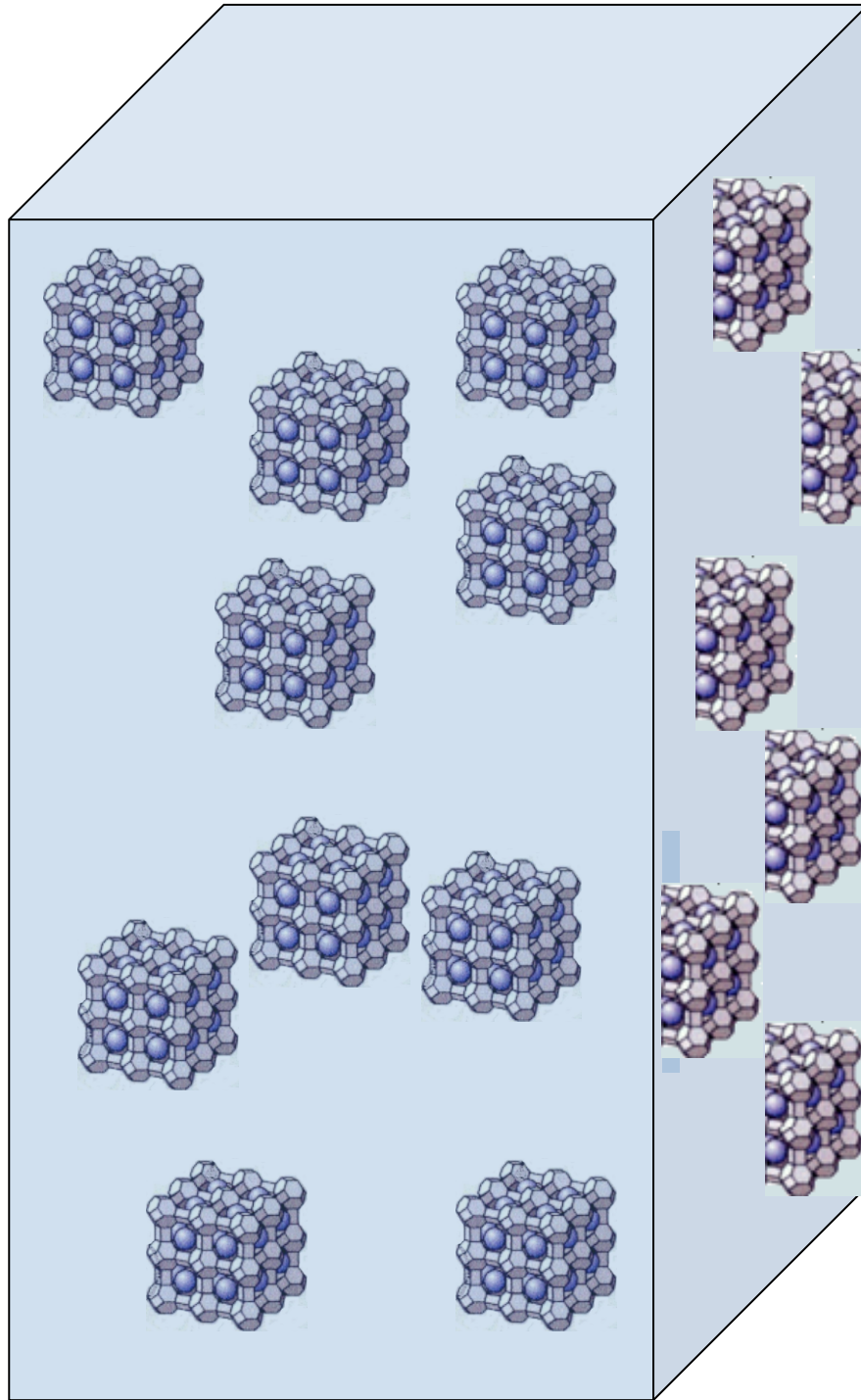
- Dishwashers
- Humidifiers
- Refrigerators
- Small appliances
- Washing machines

Building Products

- Coatings
- Insulation
- Partitions
- Security hardware

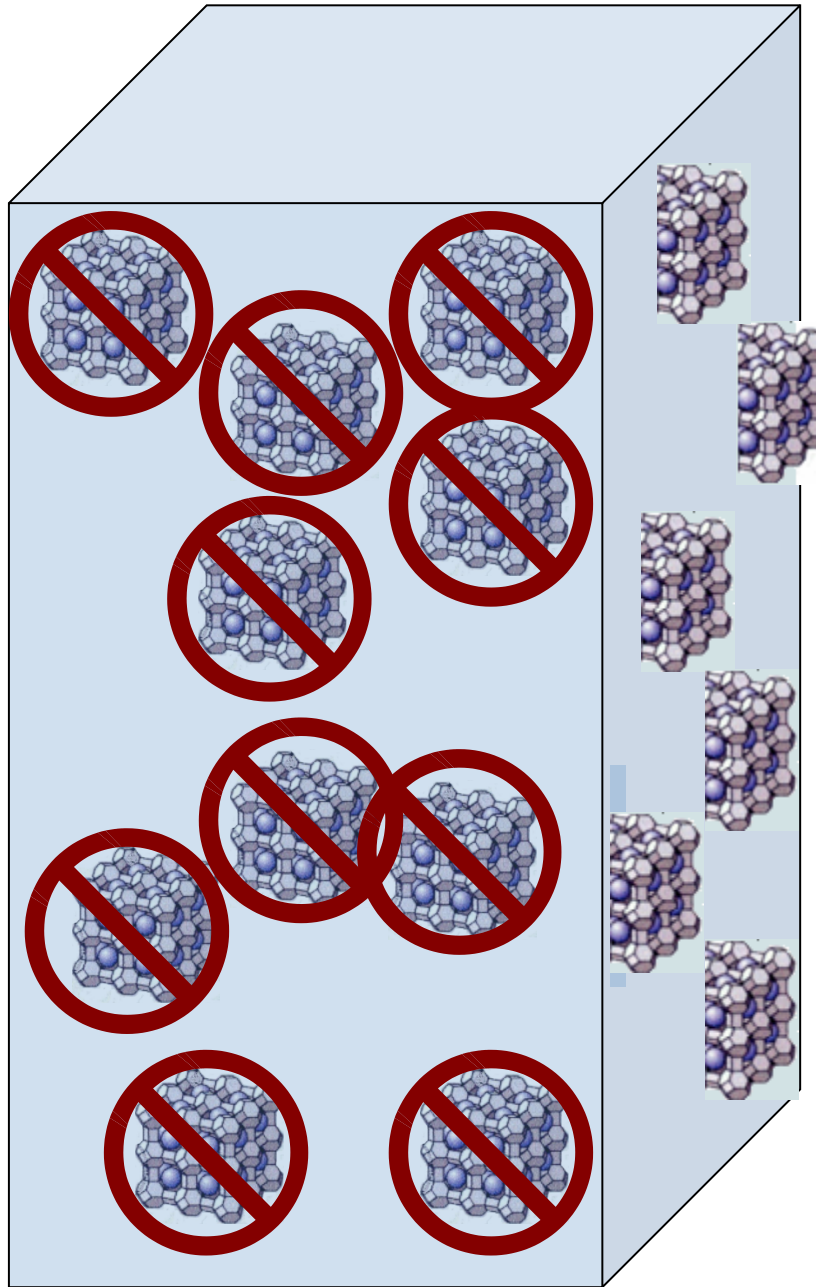
Additional Applications

- Ballpoint pens
- Brushes
- Credit cards
- Promotional products
- Textiles
- Touch screens



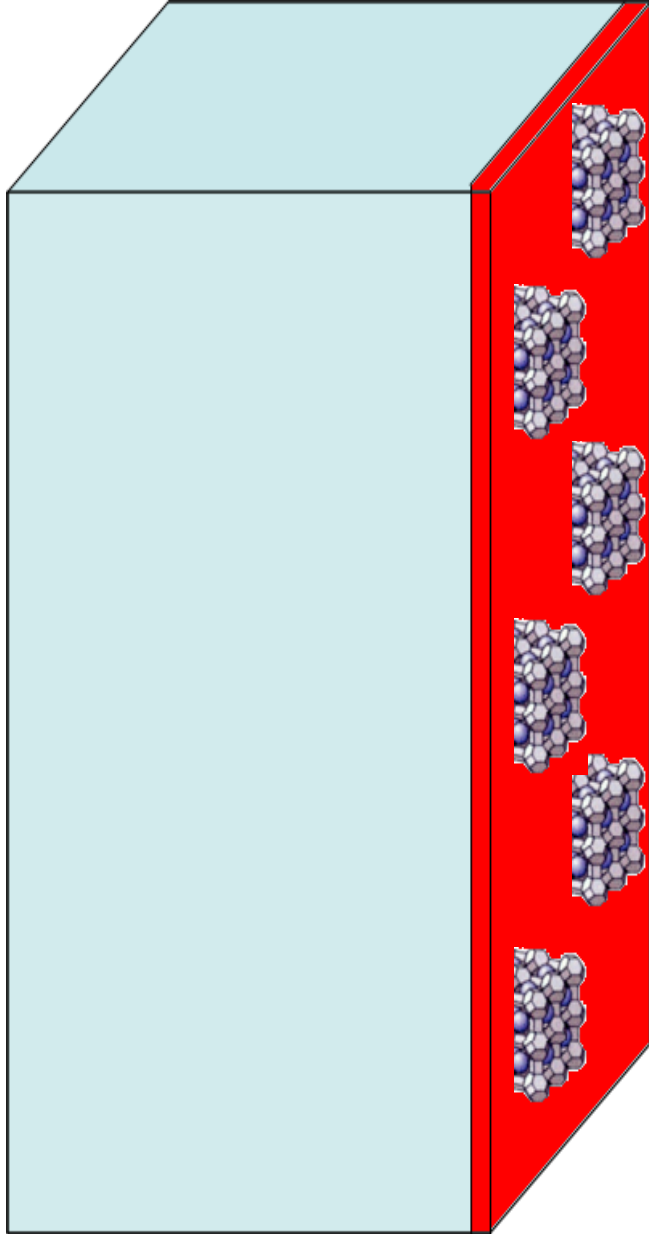
A commercial silver zeolite product

Silver Zeolite: Incorporated in Plastics



Only About

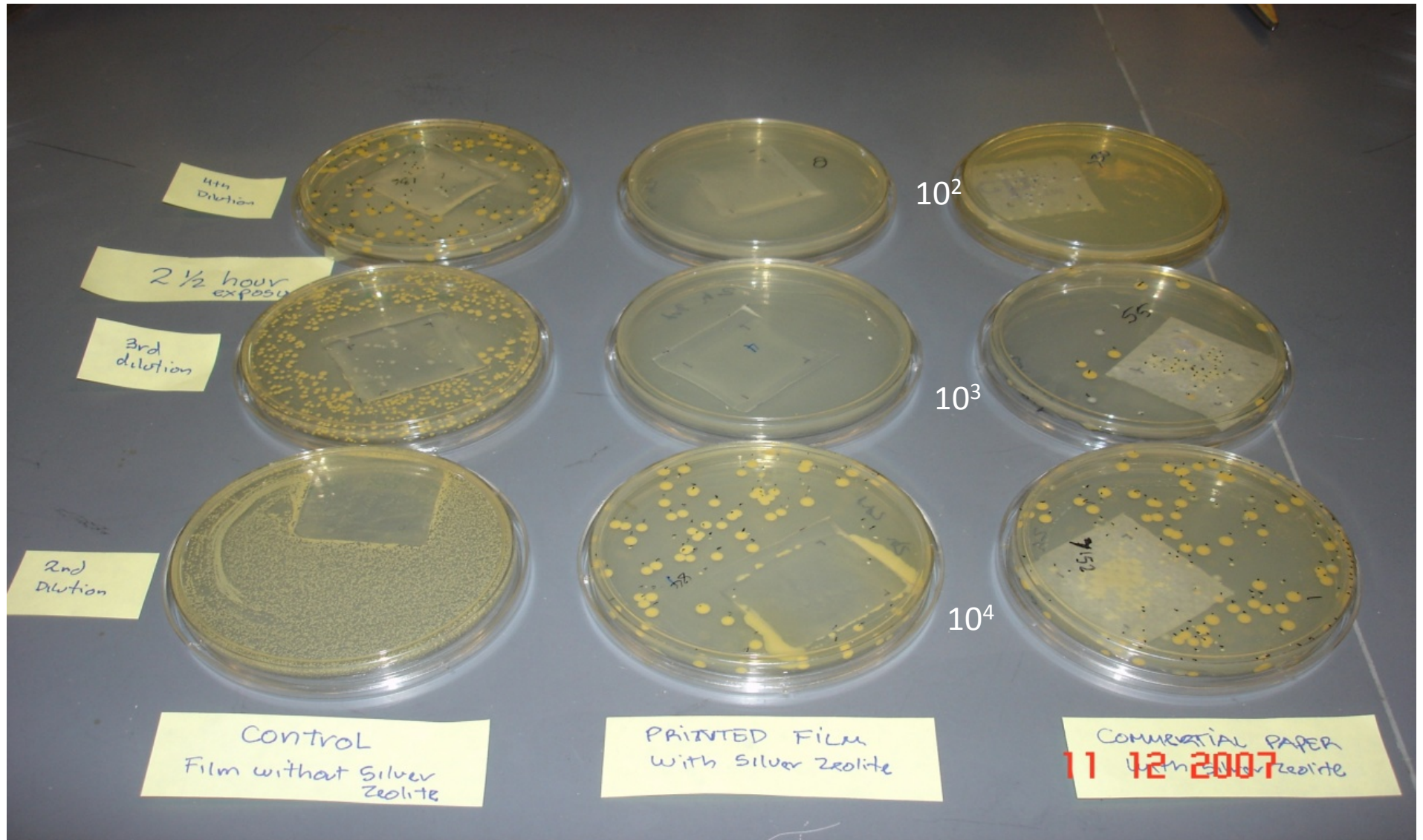
5% Active



Surface Printing

- Up to 45% of the activity available
- Does not alter the support polymer
- Can be printed in registration to minimize waste/target special areas

Printed Silver Zeolite Coupons





Diffusional Restrictions

$$T_x(t) = 1 - \frac{4}{\pi} \sum_{n=0}^{\infty} \left[\frac{(-1)^n}{2n+1} e^{-D(2n+1)^2 \cdot \pi^2 \cdot \frac{t}{4L^2}} \cdot \cos \left[\frac{(2n+1) \cdot \pi \cdot x}{2L} \right] \right]$$

Where:

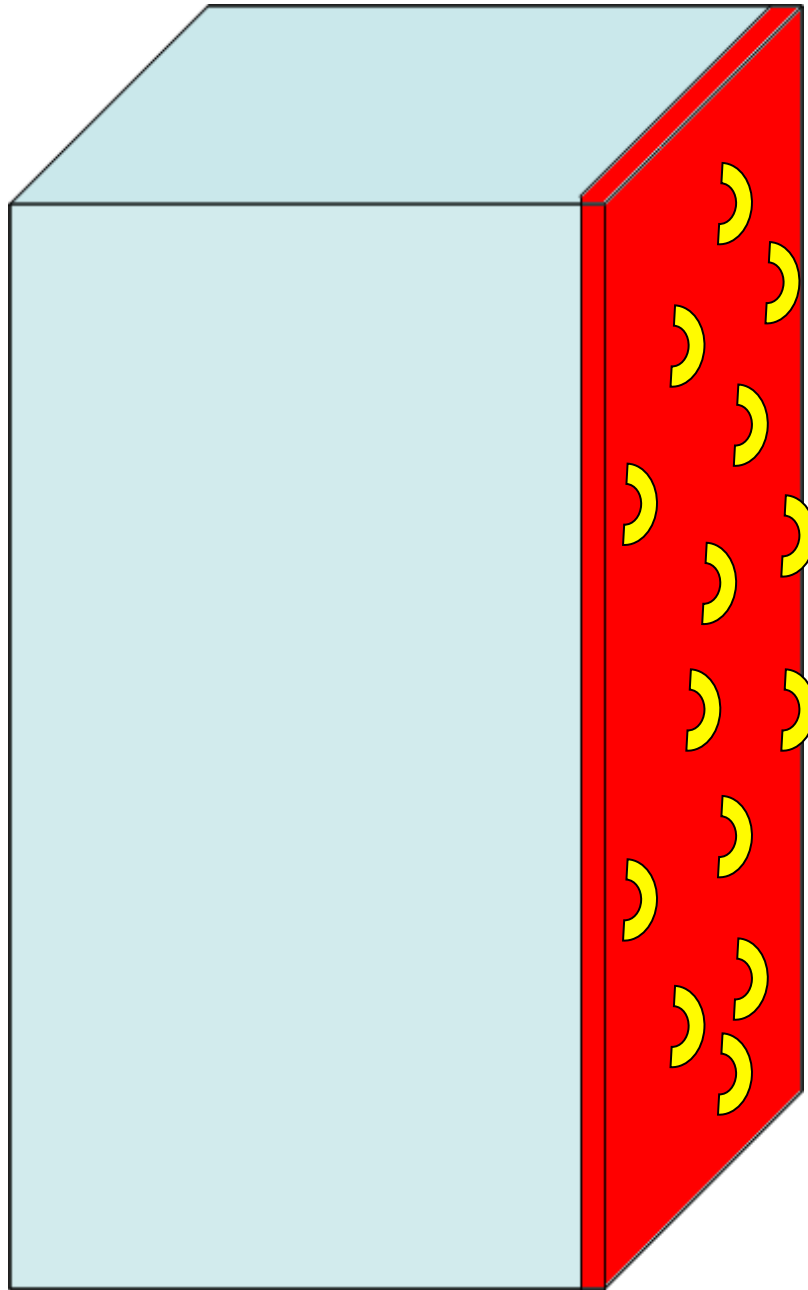
D = the thermal diffusivity

L = widest width of the particulate

x = some point where temperature

reading is desired where $x = 0$ at $1/2 L$.

t = time



Time-Released
Microcapsules

Including:

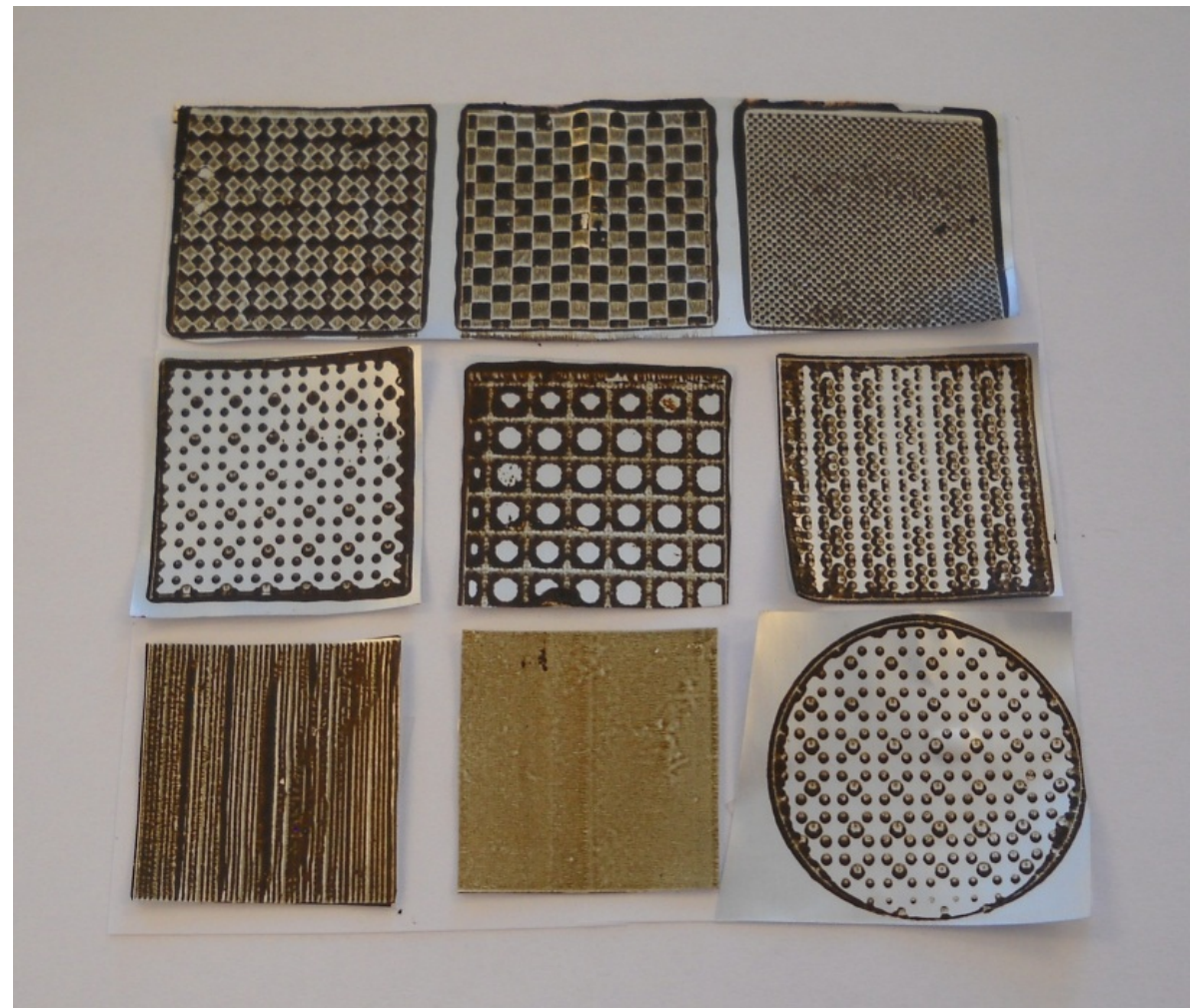
- Bacteriocins
- Nicins
- Antioxidants
- Flavors
- Soluble Enzymes

Oxygen Scavenging Iron Ink



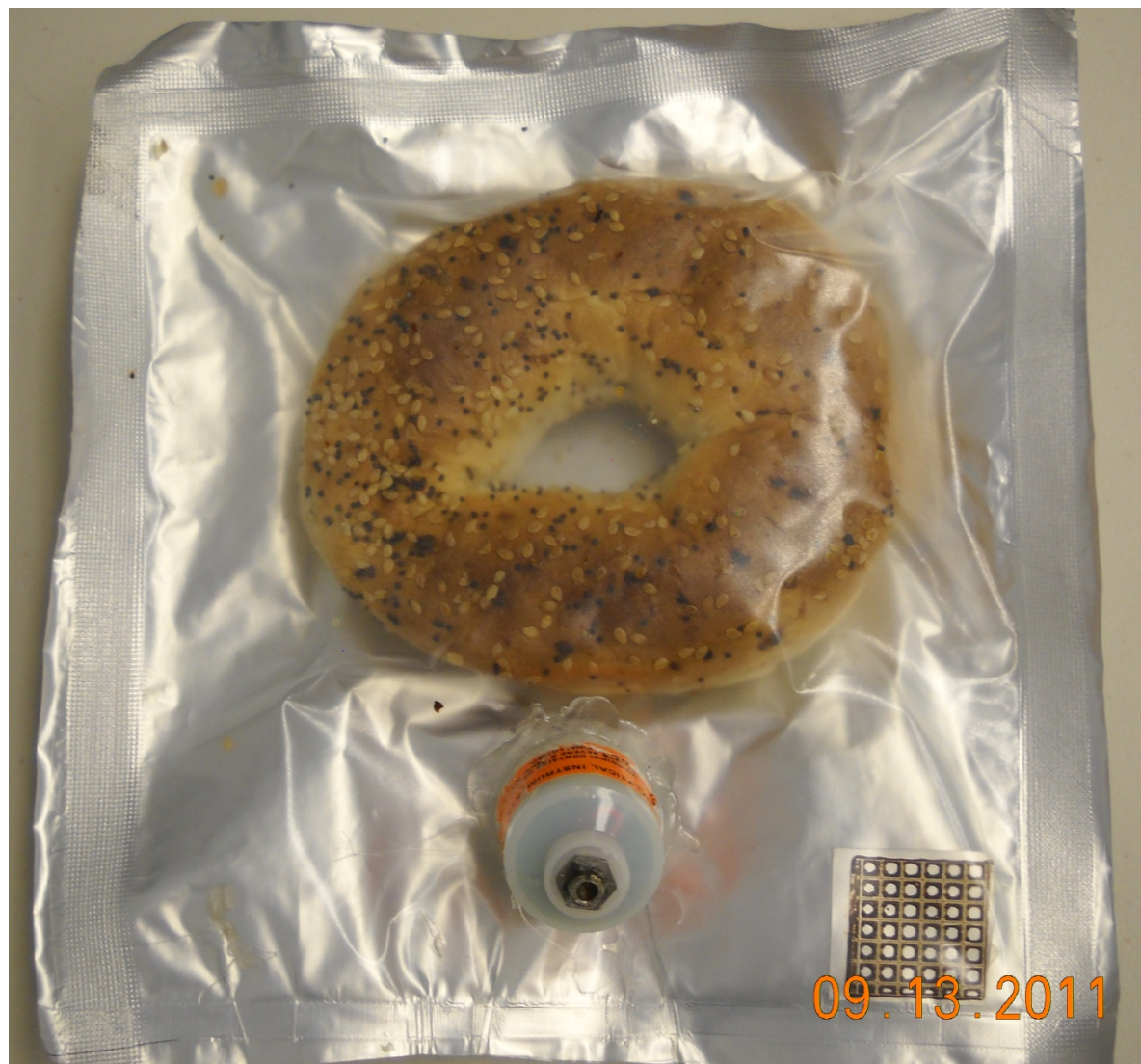
Developed for NASA to improve packaging performance for Lunar and Martian colonization programs.

- Oxidation Protection
- Shelf Life Extension
- Nutritional Protection
- Weight Reduction

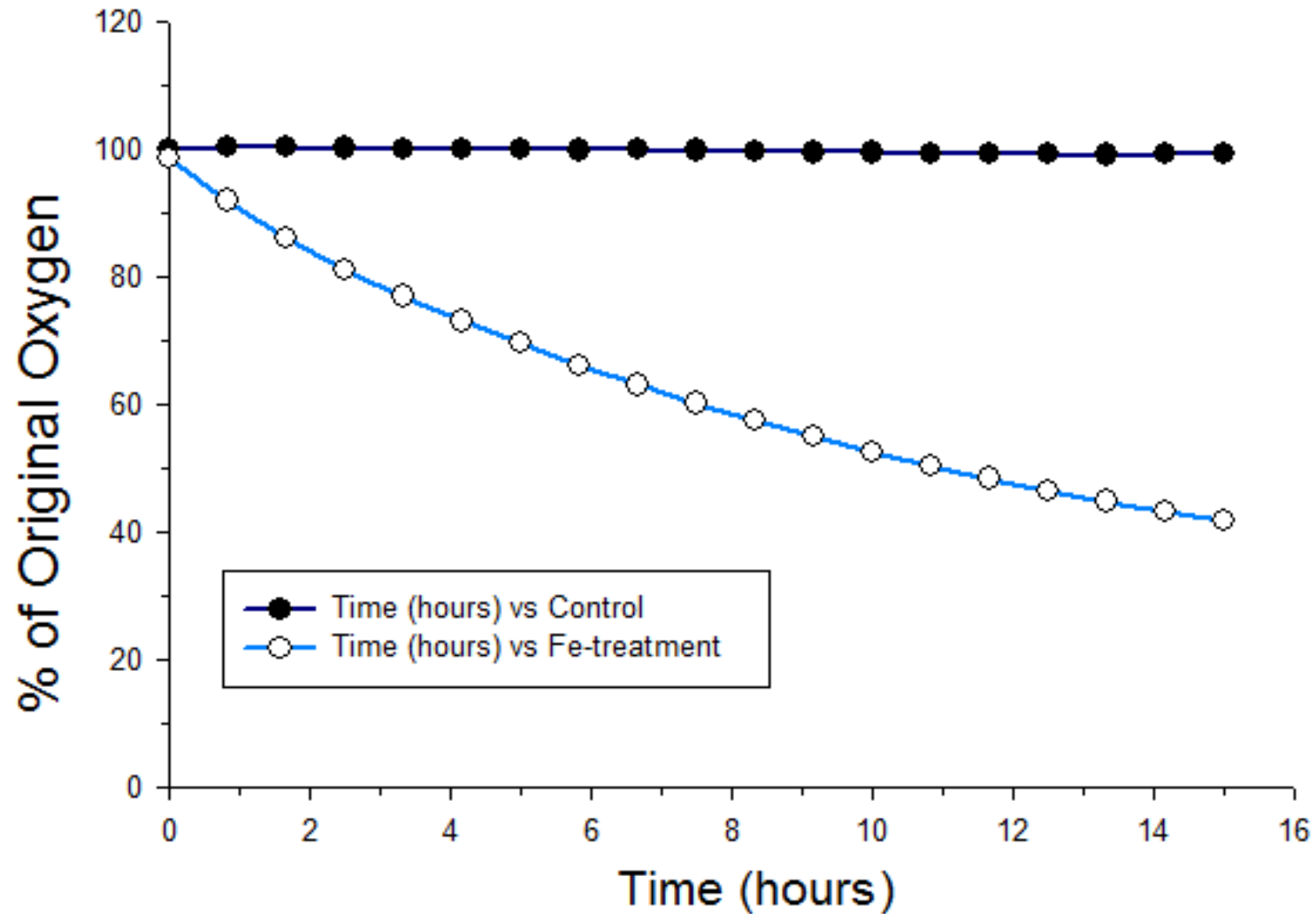




Oxygen Scavenging Iron Ink



Oxygen Scavenging Iron Ink



250 mg of printed Iron—Also controls A_w

NASA Zero Oxygen (for 5 years) Containers



Printing of Biological Activities:

Oxygen Scavenging Glucose Oxidase /Catalase Ink

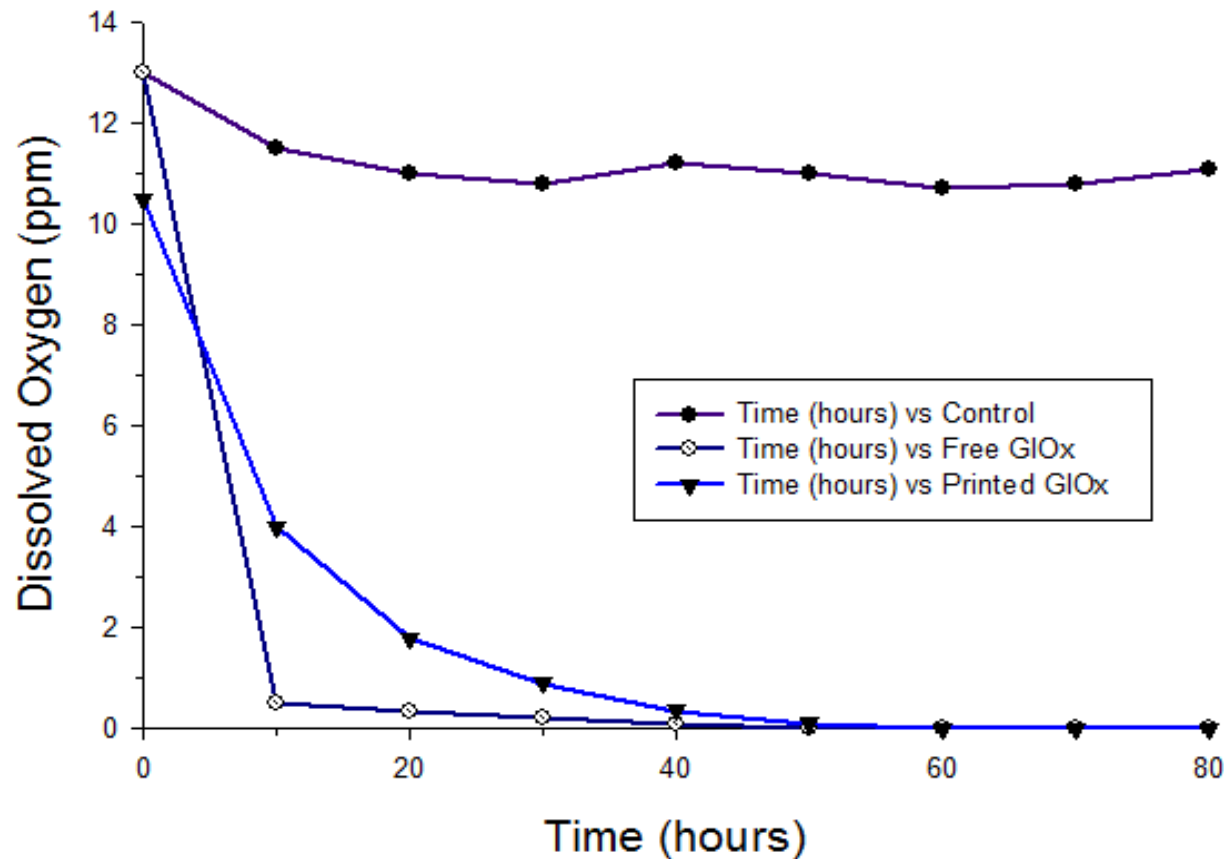
Removes head space oxygen from bags and fitments.

- Oxidation Protection
- Nutritional Protection
- GRAS enzymes



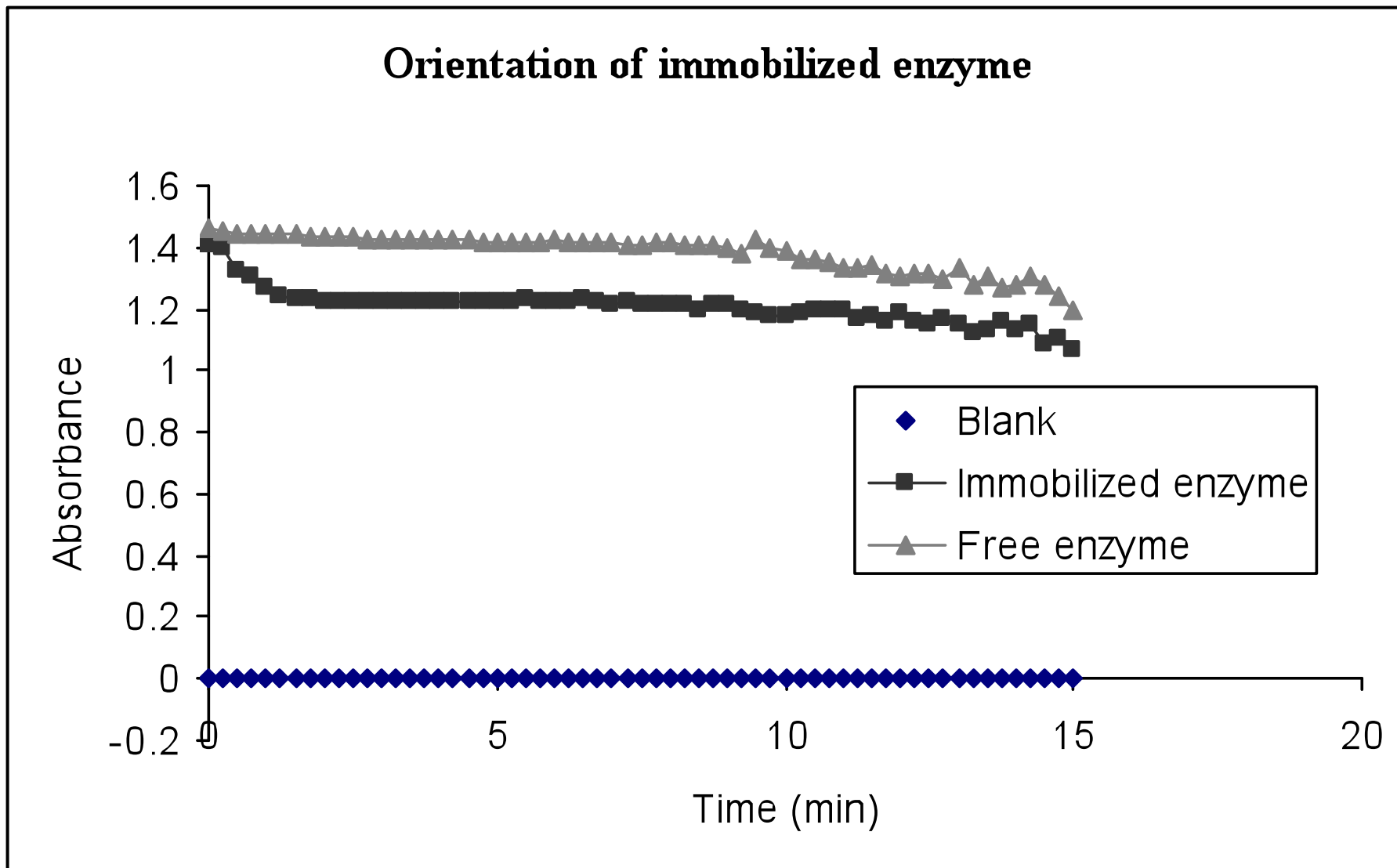


Oxygen Scavenging Glucose Oxidase Ink

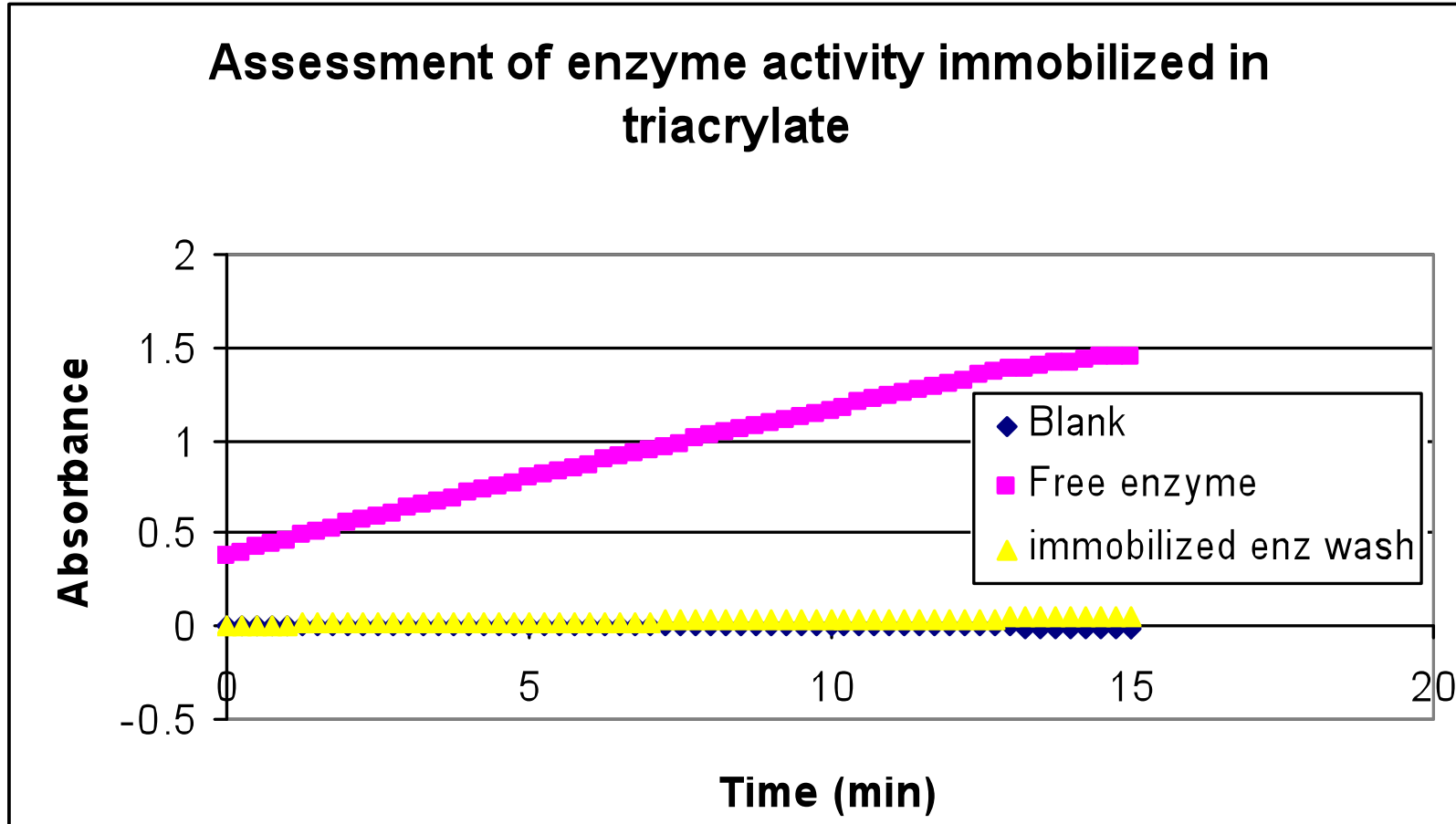


Oxygen removal by free and LDPE-printed glucose oxidase in apple juice at 4°C.

89% Retained GLOx Activity



Robustness of GLOx Binding





Surface Activation Printing

Antimicrobial Glucose Oxidase Ink

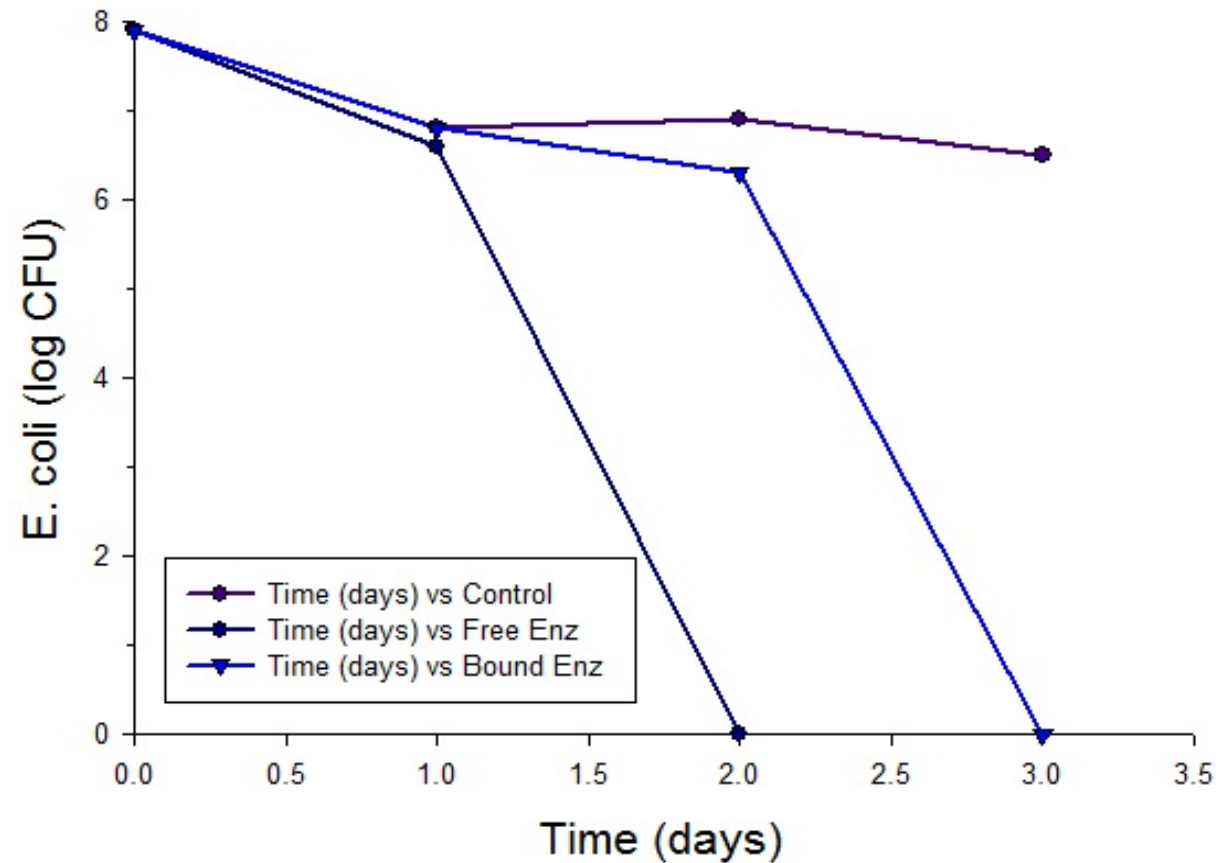
Inhibits bacterial growth in dispensing tubes and bag fittings.

- Microbial Inhibition
- Fueled by product ingredients (ie virtually no depletion)
- Resin & photoinitiator approved for food contact





Antimicrobial Glucose Oxidase “Ink”



Printed antimicrobial glucose oxidase --impact on the survival of *E. coli* O157 H7 in apple juice at 4°C.



Antimicrobial Glucose Oxidase Ink

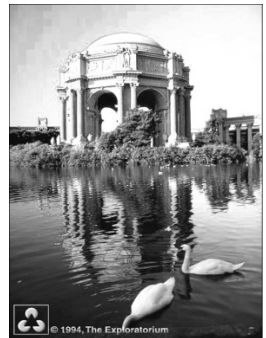
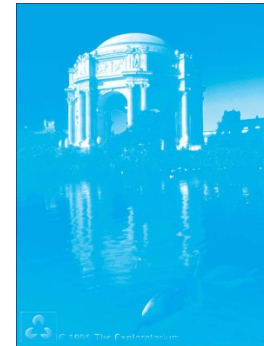
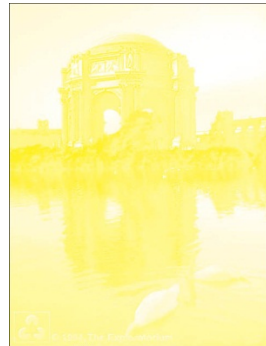


Antimicrobial GLOx Ink will eliminate microbial contaminants on
Package/dispenser surfaces between dispensing

Aseptic Dispensing --Tap Design



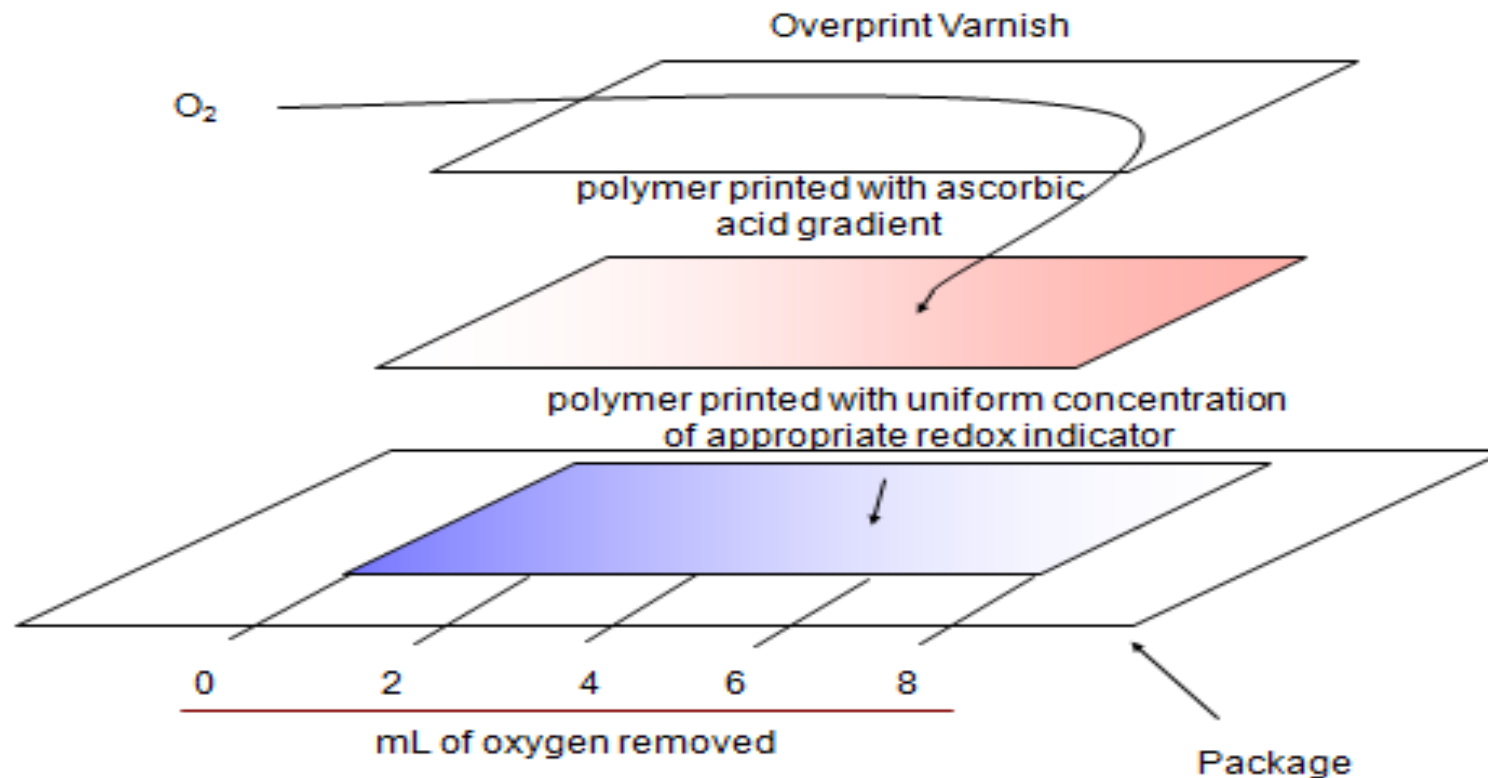
Superimposing Active Functionalities



Active inks can have layered activities and functionalities



Shelf Life Indicator

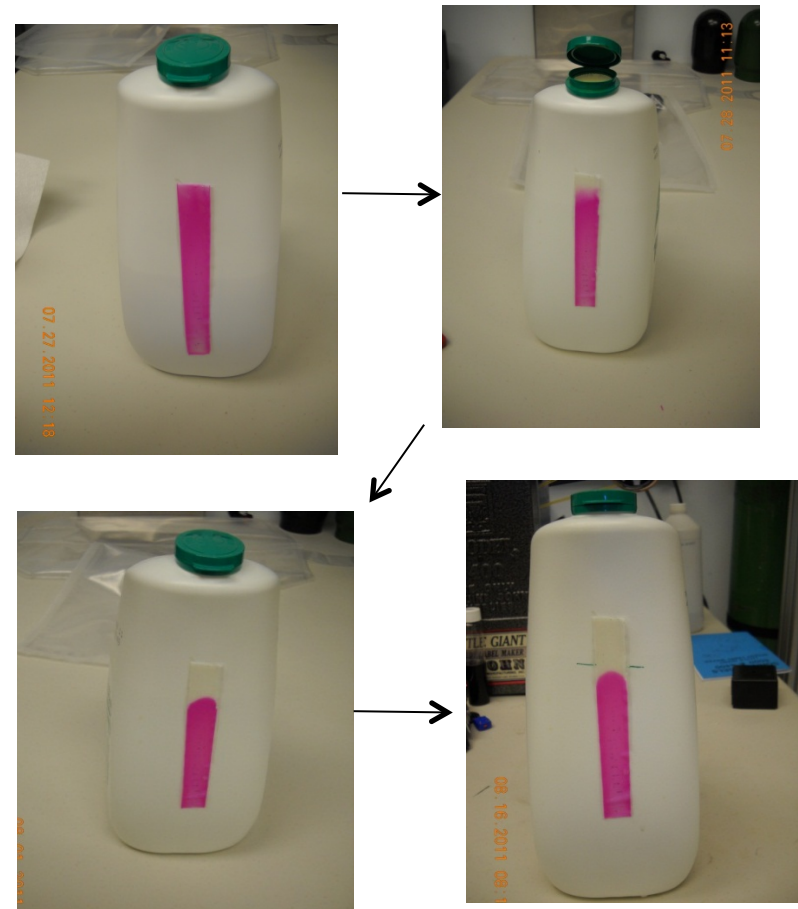


The shelf life indicator can be printed directly to the package for easy use.

Multi-surface Activation Printing

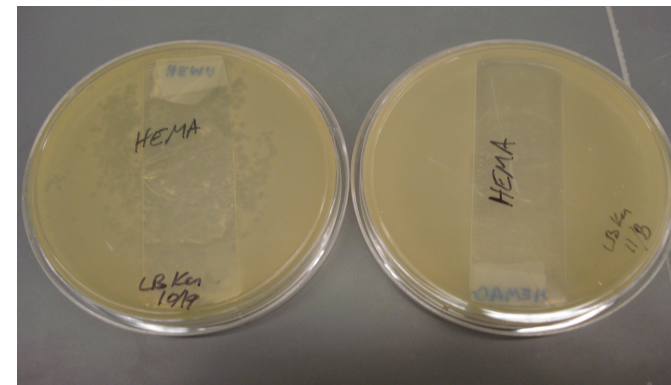
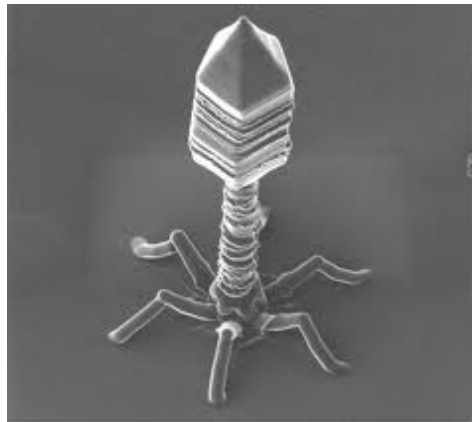
End of Shelf Life Indicator

Developed to show the progress towards the end-of-shelf-life for a product or package



T4 Bacteriophage

- GRAS Materials
- Organism Specific
- Self Dosing and Regenerative
- Highly Targeted

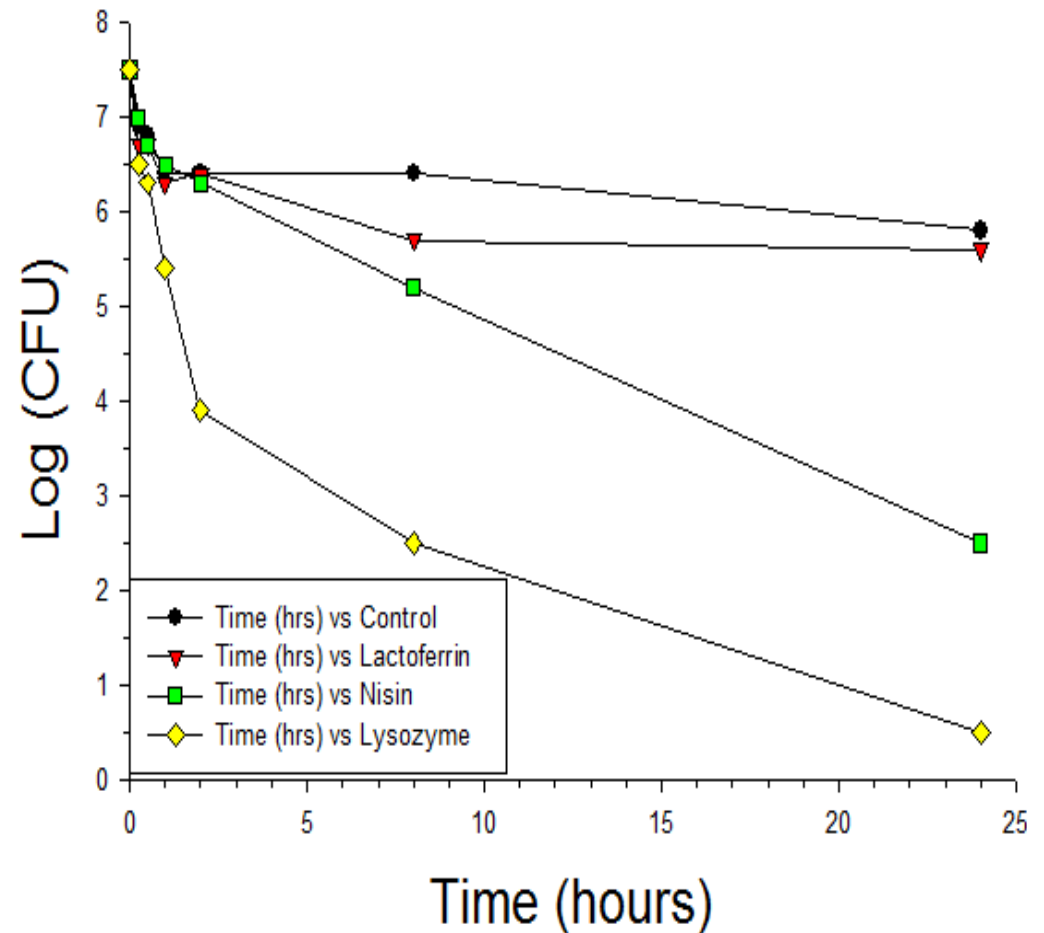


The treatment and control of the T4 Bacteriophage (left to right respectively)



Bacteriocins

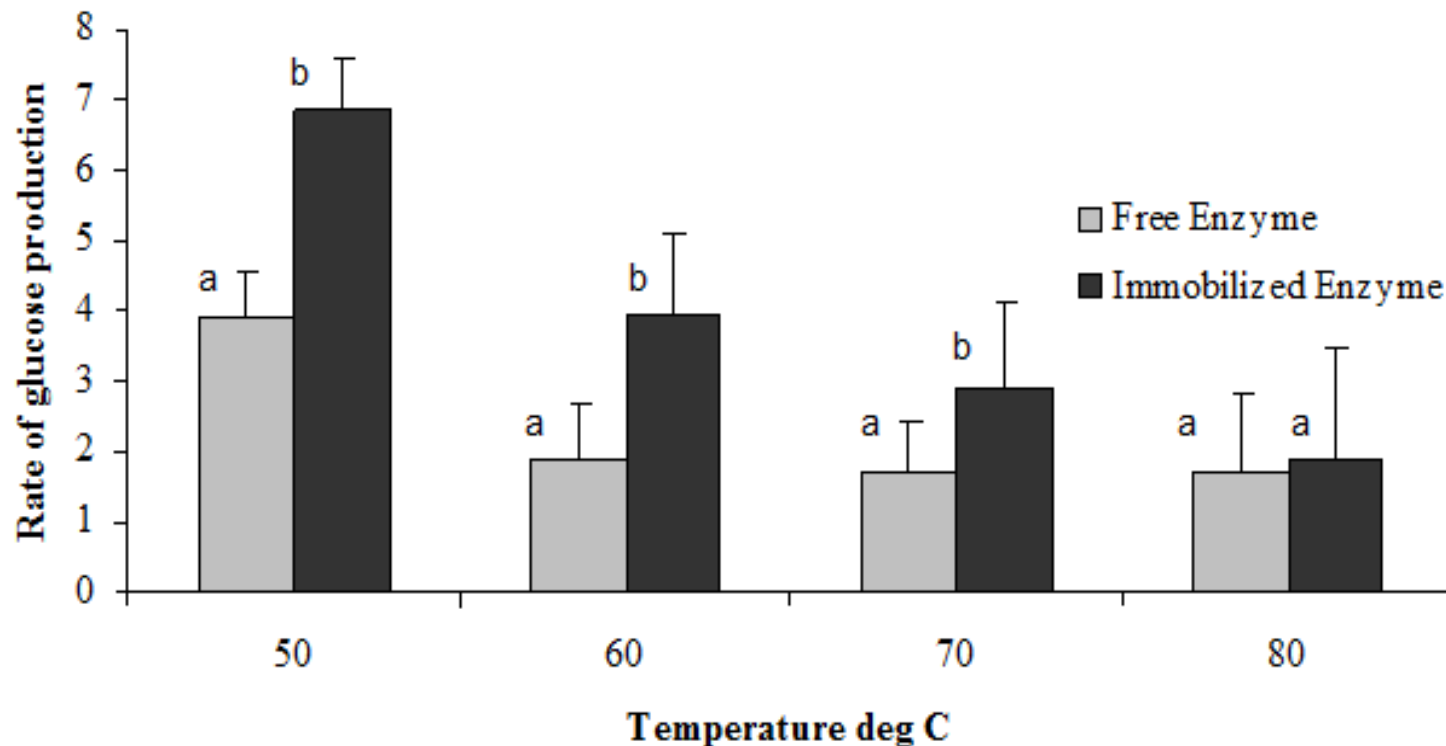
- GRAS Materials
- High Activity and Broad Spectrum
- Temperature Stable
- Inexpensive
- Dairy Applications
- Direct Food Contact Applications



The effect of printed bacteriocins
on the survival of *L.*
monocytogenes



Lactase: Activity Printed vs Free



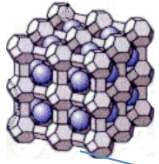
* The values with the same alphabet indicate the results that are not significantly different.

Regulatory Issues

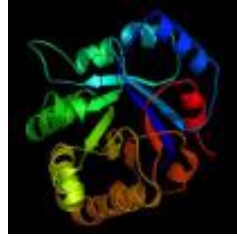
FCN 722

Specifically, FCN 772 clears for direct food contact any mixture of one or more of tripropylene glycol diacrylate (TPGDA), trimethylolpropane triacrylate (TMPTA), trimethylolpropane ethoxylate triacrylate (TMPEOTA), and epoxy diacrylate and optionally, Esacure One photoinitiator, cured by either ultraviolet (UV) or electron beam (EB) irradiation. Moreover, the applied formulations may include any combination with other reactants, polymers, additives, pigments, etc., already permitted for the intended use under 21 CFR.

Chemical



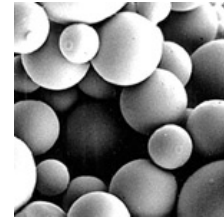
Biochemical



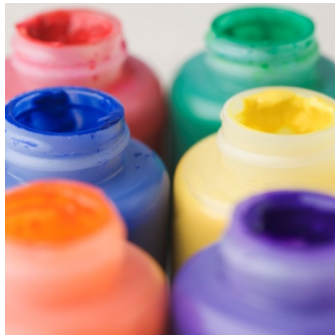
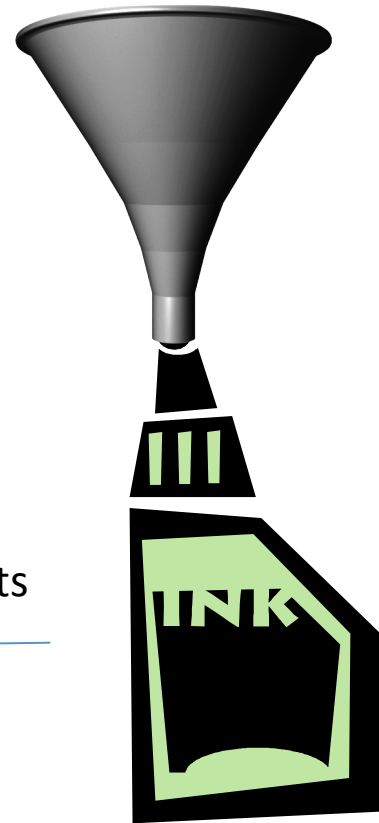
Biological



Micro Capsules



General Approach



Remove Pigments

Energy Curable
Print Resins



Active “Inks”

