

We know surface chemistry

Precisely modify any surface

*We can do things no one else
can do*

... not even Nature





Omniphobic Coatings

Our superomniphobic coating enhances the performance of a variety of surfaces, including glass, plastic, cloth, metals, and other materials. It is easy to clean or, in many cases, self-cleaning. Surfaces that display contact angles greater than 150° along with low contact angle hysteresis with essentially all high and low surface tension liquids, including water, oils and alcohols, are known as superomniphobic surfaces. Such surfaces have a range of commercial applications including self-cleaning surfaces, non-fouling surfaces, stain-free clothing, drag reduction, corrosion prevention, and separation of liquids.

At HygraTek we have developed some of the most durable, and economical, superomniphobic surfaces. The developed coatings can repel non-Newtonian liquids (e.g., viscoelastic polymer solutions) in addition to a wide range of Newtonian liquids including concentrated organic and inorganic acids, bases and solvents. Virtually all liquids – organic or inorganic, polar or non-polar, Newtonian or non-Newtonian – easily roll-off and bounce on our surfaces, thereby making our surfaces ideal candidates for effective chemical shielding. We have also developed one of the first methodologies for the fabrication of flexible, highly transparent (optical transmission $>90\%$), superomniphobic surfaces that can repel a range of low and high surface tension liquids.

HygraTek® has developed a patent-pending approach to create superomniphobic surfaces with following characteristics:

- Contact angle (CA) ≥ 150 and contact angle hysteresis (CAH) < 4 for essentially all liquids (water, alcohols, acids, bases, oils etc.)
- Thin layer superomniphobic coating has minimal weight gain ($< 0.3\%$ of the substrate weight)
- Superomniphobic surfaces are stable between -50°C and 250°C
- Can be easily applied by contractors with fast curing time ($< 3\text{ h}$)
- Exhibits excellent durability and abrasion resistance based on Taber abrasion results
- Highly insulating and non-conducting
- Minimal maintenance, cost-effective compared to other products in market

The durable superomniphobic surfaces developed by HygraTek® are extremely unique. The coating can be sprayed-on, dip-coated, spin-coated or etched onto virtually any substrate, enabling applications from stain-resistant textiles, drag-reduction, biofouling prevention, corrosion prevention, and chemical/biological protection.

Our coatings can even be an excellent solution for improving the high voltage, wet-limit performance and longevity of different dielectric and conducting materials used in Very Low and Low Frequency (VLF/LF) antenna components.

Icephobic Coatings

Moisture, whether ice or water, leads to catastrophic failures in aircraft engines. Ice adhesion increases drag, requiring millions of dollars in wasted fuel consumption. In addition, ice formation, as well as undesirable surface wear or adhesion, adversely impacts the aerodynamic performance of wind turbines.

HygraTek® can solve these problems. Our ice-phobic coatings have the **lowest ice adhesion values ever reported (<5kPa)**!



We have developed a single-step, sprayable ice-phobic coating that is transparent, easy to apply, and will bond to nearly any surface (including glass, metals, polymers, ceramics, etc.). Incorporating HygraTek's® ice-phobic coatings into aerospace and naval applications present new solution opportunities for intractable problems.

Ice accretion and subsequent removal is a safety hazard for aircrafts, power lines, motor vehicles, marine structures, communication towers and wind turbines. The most common methods of ice removal are extremely energy intensive. Mechanical removal, electro-mechanical expulsion, thermal removal and chemical removal are the industrial standards of today. Each method involves either inputting enough force to break off any accreted ice, or inputting enough energy to melt the ice. Thus, there exists a strong need to develop passive, energy-efficient methods for the removal of ice from any surface.

The adhesion between ice and many materials has been extensively studied. To quantify the ice adhesion strength of a material, a known area of ice, frozen on the material, is sheared off, and the practical work of adhesion, W_a (also called the ice-adhesion strength) is measured. Most common metals like aluminum or steel have extremely high ice adhesion strengths, of $W_a \sim 1400$ kPa, respectively. On the other hand, polymers, such as Teflon, display ice-adhesion strengths of $W_a \sim 240$ kPa. Based on traditional predictions, the best ice-phobic surfaces should possess ice-adhesion strengths of $W_a \sim 100$ kPa.

In our work we have circumvented the theoretical lower limit of ice adhesion strength, discovering a new physical phenomenon that allows us to create icephobic coatings with ice adhesion strengths as low as 0.2 kPa. Our coatings show a ~ 300 fold reduction in W_a over plain aluminum metal, and a 400% reduction in W_a over any other published value of W_a . Further, even after repeated icing – de-icing cycles, extensive Taber abrasion, thermal cycling, salt exposure, and acid/ base exposure, the ice adhesion strength of our coatings is maintained, both in laboratory settings and even in Michigan wintery conditions over several months of exposure.

Specialty Coatings

Chemical / Biological Protection -

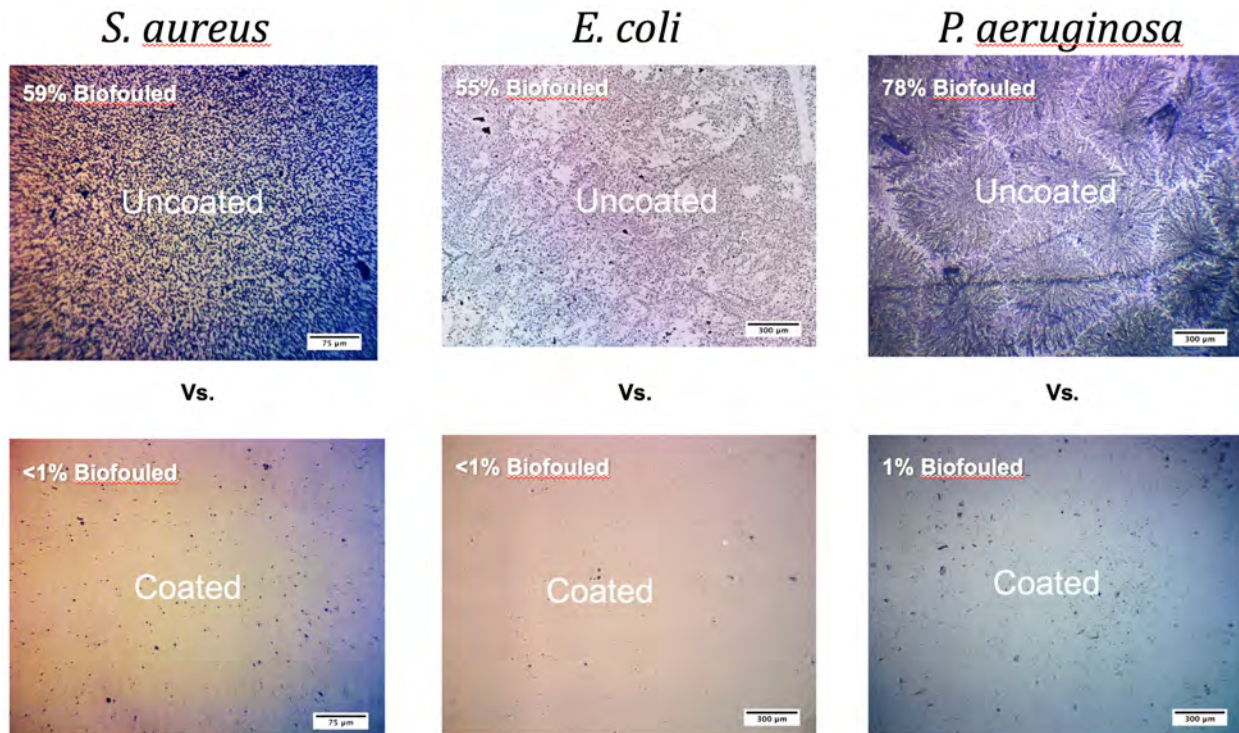
HygraTek® membranes are omniphobic, and survive extreme acids and base environments. They are ideal for chemical shielding and corrosion prevention.

Drag Reduction - Our coating technology has been proven to reduce drag by up to 56 percent, creating an outstanding return on investment.

Biofouling Prevention - Biofouling prevention systems protect a ship's exterior by preventing marine organisms and other debris from attaching to, or damaging, the ship's hull. HygraTek® membranes and coatings purify water from oily effluents, allow for oil in water sensor detection, maximize water reuse and yield a 5 to 10-fold increase membrane lifetime.



Antimicrobial - Low adhesion surfaces reduce disease transmission. Bacteria, for example, will grow on tissue culture glass and plastic, but not on HygraTek®-coated surfaces.



All images taken after 10 days of microbial growth

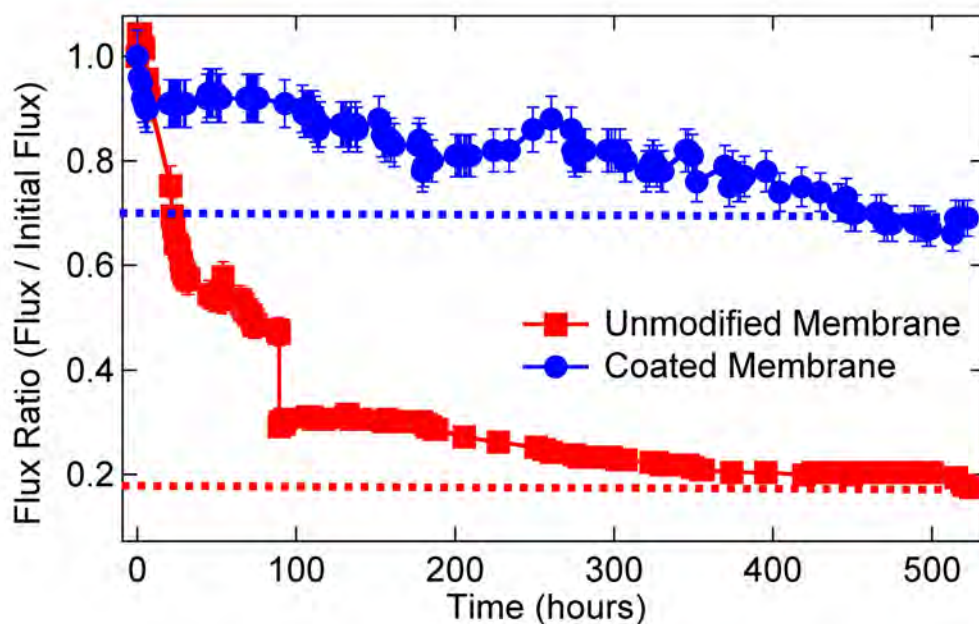
Membranes



There is a critical need to develop new energy-efficient solutions for the separation of oil-water mixtures, including those stabilized by surfactants. Traditional membrane-based separation technologies for oil-water mixtures are energy-intensive and further limited, either by fouling or the inability of a single membrane to separate all types of oil-water mixtures. The ideal membrane to effect gravity-driven separation of oil-water mixtures is expected to be both hydrophilic and oleophobic, in air and when submerged under water. Such membranes would allow the higher density liquid (water) to flow through, while retaining the lower density liquid (oil). However, as water possesses a significantly higher surface tension than various oils, most membranes that prevent the permeation of oils, also prevent the permeation of water.

At HygraTek, we have developed the **first-ever** reconfigurable membranes that, counter-intuitively, are both superhydrophilic (i.e., water contact angles @ 0°) *and* superoleophobic (i.e., oil contact angles $> 150^\circ$). These membranes were designed through the systematic tailoring of membrane porosity and the membrane-water interfacial energy. The developed fouling-resistant membranes are able to separate all types of oil-water mixtures, with $> 99\%$ separation efficiency, using a single membrane. The developed membranes can be used for the continuous, solely gravity-driven separation of surfactant-stabilized oil-water emulsions, with a separation efficiency ³ 99.9%.

Our coatings can be applied onto any existing porous substrate, such as filter papers, paper, fabrics and wire-meshes. The developed membranes enable solely gravity driven clean-up of oil spills, and the energy efficient separation of a range of different emulsions produced during wastewater treatment, fracking, chemical synthesis, and produced water disposal. Beyond this, our membranes can also be used to maximize water re-use and prolong membrane life, enhancing your return on investment (ROI).



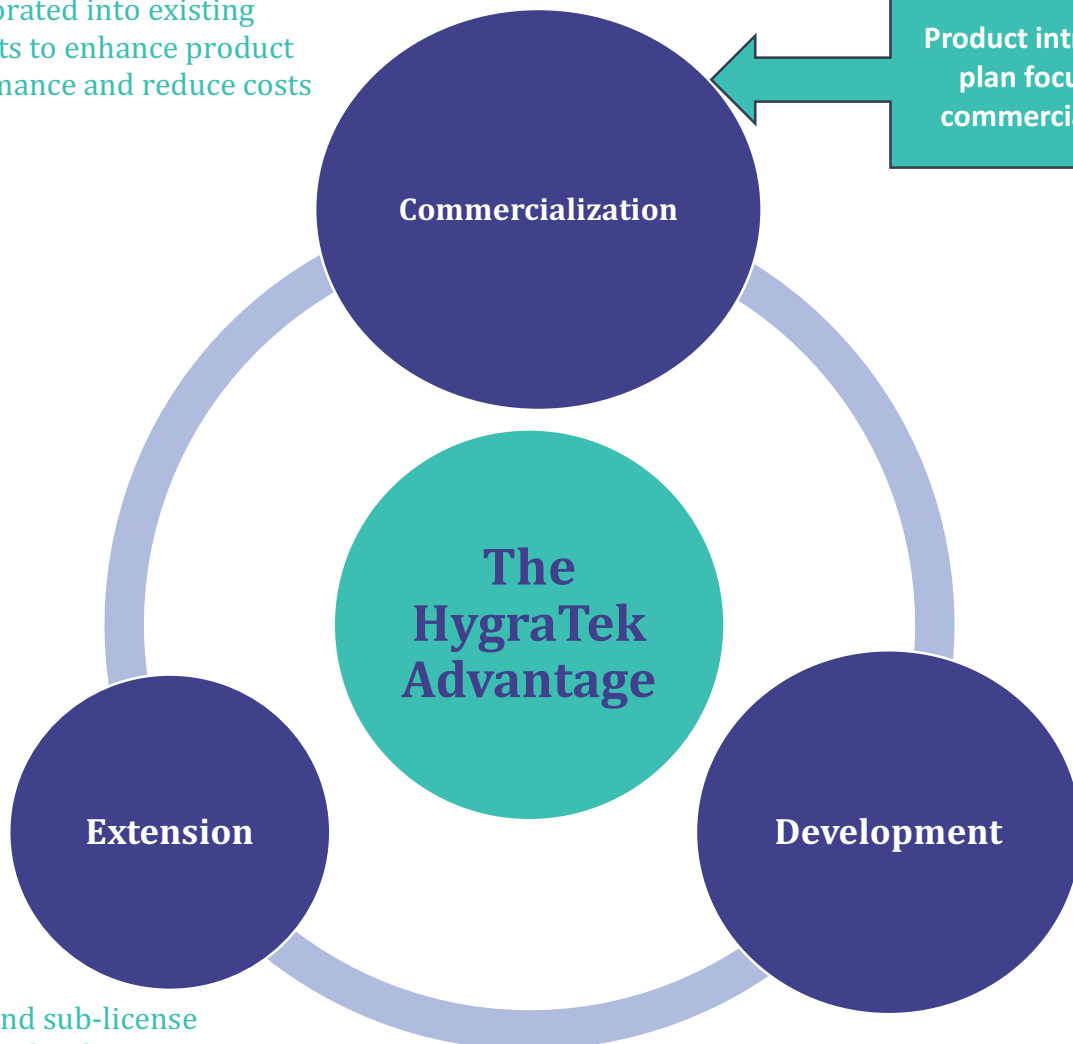
Development Approach



Commercialization:

- New technology will be derived from commercially-ready, individual components integrated in a unique matter
- Create new technology that will be incorporated into existing products to enhance product performance and reduce costs

Product introduction plan focuses on commercialization



Extension:

- License and sub-license existing technologies to individual companies in select geographic and industry-specific areas on an exclusive and non-exclusive basis
- Technology improvements will be granted back to HygraTek for all fields outside of licensees' field

Development:
Extend technology through further development and integration to create a commercially-ready product

Accelerating Game Changing Solutions



Who Are We?

HygraTek® is currently developing the next generation of cost-effective and energy-efficient liquid separation solutions combined with a patent-pending membrane technology that essentially strains oil from water. In addition, HygraTek® has developed coating technology that surpasses even nature's ability to repel and attract various substances in unique combinations across the wettability landscape.

The company, which is privately held, was established in 2013. It has its corporate Research & Development center in the North Campus Research Center at the University of Michigan (Ann Arbor) campus, with its business development and marketing units located in Chicago.

Who are HygraTek's® partners?

HygraTek's® strategic partners include international manufacturing relationships, advanced technology development entities, and renewable energy product engineering and installation firms.

HygraTek® will utilize CogniTek® and TriTek® to exclusively develop and market value-added relationships within the energy and food sectors to accelerate commercialization and global reach. We are looking for strategic partners who are interested in developing applications in the following industries:

- Manufacturing
- Aerospace
- Automotive
- Military
- Nautical/Marine
- Water Treatment/Processing
- Consumer Appliance
- Textiles/Clothing
- Building Products
- HVAC/R
- Medical Technology/Healthcare
- Food Service

Contact us at sales@hygratek.com