

# Technologies Available for Licensing

## PAINTS & COATINGS 2010

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## PATENTED TECHNOLOGIES AVAILABLE FOR LICENSING (Paints and Coatings)

### LIST OF TECHNOLOGIES

INVENTION TITLE	Tech No.	Application(s)
• Novel Amphiphilic Fouling Release Coatings	RFT 319	Marine
• Polymers Derived From Vegetable Oils Exhibiting Several Superior Mechanical Properties	RFT 318	Architectural
• Novel Marine Fouling Release Polyurethane Coatings	RFT 301	Marine
• A polymer for non-fouling or fouling release type coatings	RFT 283	Marine, Architectural
• Anti-microbial coatings containing chemically bound biocide moieties	RFT 282	Biomedical
• Multifunctional 'dual action' anti-microbial polysiloxane coatings for biomedical applications	RFT 260	Biomedical
• Quaternary ammonium functionalized POSS compounds as anti-fouling, anti-microbial agent	RFT 242	Biomedical
• UV-Curable Low Surface Energy Coatings	RFT 254	Marine, Architectural
• Antibacterial Siloxane Polymer Containing Tethered Levofloxacin	RFT 232	Biomedical
• Siloxane-urethane coatings for anti-graffiti and marine antifouling applications	RFT 231	Marine, Architectural
• Novel commercial grade hybrid coatings with enhanced hardness, thermal resistance and mechanical properties	RFT 225/240	Structural
• Unique anti-fouling and anti-microbial coatings for marine applications	RFT 214	Marine, Biomedical
• Non-toxic and durable foul-release coatings	RFT 197	Marine, Architectural
• Conductive Ink Compositions that can be hardened using UV radiation	RFT 182	Electronics
• Novel environment friendly coatings for marine and medical applications	RFT 179	Marine, Biomedical

## LIST OF TECHNOLOGIES (CONTINUED)

• Novel "carrier gas" sensitizers for improved laser ablation performance of coating films	RFT 178	Electronics
• Unique coatings (with phase separation properties) for use as foul release and anti-graffiti paints	RFT 158	Marine, Architectural
• Polysiloxane-poly lactone coatings with anti-fouling properties for ships and boats	RFT 157	Marine
• Hard, glossy water dispersible urethane epoxy coating	RFT 154	Architectural
• Novel radiation curable sensitizers for improved laser ablation performance of cross-linked films	RFT 153	Electronics
• Novel coatings for outdoor bronzes: features superior protection and easy removal	RFT 141	Structural
• Novel environment friendly (chromium-free) primer coating for corrosion protection	RFT 140	Anti-corrosion
• Novel environmental friendly coatings for marine applications	RFT 133	Marine
• New family of organo-metallic single source precursors for inorganic films, coatings, and powders	RFT 65	Architectural
• Novel coating binders comprising liquid crystalline enhanced polymers	RFT 55	Architectural
• Novel siloxane reactive diluents for cationic UV coatings	RFT 27	Architectural
• Vegetable seed-oil based coating for superior corrosion protection	RFT 26	Anti-corrosion

## Brief Descriptions

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RFT 319

### NOVEL AMPHIPHILIC FOULING RELEASE COATINGS

This invention involves the formulation of unique fouling release polysiloxane coatings that contain fluorinated segments and poly(ethylene glycol) segments which in turn demonstrate a synergistic enhancement in fouling-release properties.

Conventional polysiloxane fouling-release formulations provide good release of macrofoulers such as barnacles but exhibit poor fouling-release of slimes. This modified polysiloxane shows good fouling-release toward both barnacles and slimes. Also, it has been shown that conventional polysiloxane fouling-release coatings typically utilize a silicone oil in the formulation to enhance fouling-release properties. The silicone oil eventually leaves the coating and fouling-release performance is reduced. This invention provides good fouling-release without the use of silicone oils which enables longer life for its fouling-release performance.

RFT 318

### POLYMERS DERIVED FROM VEGETABLE OILS EXHIBITING SEVERAL SUPERIOR MECHANICAL PROPERTIES

NDSU Scientists have invented a novel soybean based polymer polyVESFA (vinylether of soybean oil fatty acids) that has been shown to exhibit several superior properties from conventional soybean oil. polyVESFA has many more fatty ester branches per molecule than soybean oil that can be used to great advantage for many applications such as coatings and composites. PolyVESFA has been shown to exhibit superior mechanical properties, modulus, hardness, chemical resistance, corrosion resistance and stain resistance. Besides these characteristics, polyVESFA exhibits reduced shrinkage upon cure and enhanced adhesion capabilities due to its higher molecular weight and higher number of fatty ester branches. Additionally, polyVESFA offers tremendous potential for desirable tailoring of the polymer as it can be copolymerized with other vinyl ether monomers.

## NOVEL MARINE FOULING RELEASE POLYURETHANE COATINGS

Scientists at NDSU have recently synthesized and formulated a series of Amphiphilic polyurethane (APU) coatings that show excellent fouling release properties as compared to commercially available coatings. These coatings are made by crosslinking isocyanate oligomers with synthesized amphiphilic polyols using typical urethane catalysts. The reason for the good fouling release performance of these coatings is currently under investigation and can be based on the following hypotheses:

- A. Formation of a mobile water layer at the coating surface due to the migration of the hydrophilic polymeric segments to the coating-water surface under water.
- B. Presence of both hydrophilic and hydrophobic polymeric segments on the coating surface “confuse” the marine organisms during the probing and attachment process.

## A POLYMER FOR NON-FOULING OR FOULING-RELEASE TYPE COATINGS

The invention discusses the synthesis of a novel zwitterionic/amphiphilic pentablock copolymer for use in coatings formulations. This penta-block copolymer was synthesized with the necessary properties to qualify as a possible candidate for non-fouling or fouling-release type coatings. The invention combines the low surface energy of PDMS and the protein resistance properties of both zwitterionic and amphiphilic compounds into a single copolymer that makes it an excellent candidate for a non-fouling marine coating.

## ANTIMICROBIAL COATINGS CONTAINING CHEMICALLY BOUND BIOCIDES MOITIES

The invention relates to novel antimicrobial environmentally friendly coatings that are derived from acrylic polyols that contain chemically bound (tethered) biocide moieties. The coatings show antimicrobial activity towards various microorganisms including gram-positive and gram-negative bacteria, diatomaceous algae and opportunistic fungal pathogens. These paints can be suitable for biomedical and/or marine applications.

## MULTIFUNCTIONAL 'DUAL ACTION' ANTIMICROBIAL POLYSILOXANE COATINGS FOR BIOMEDICAL APPLICATIONS

This invention pertains to 'dual action' antimicrobial polysiloxane coatings having a leachable antimicrobial agent in conjunction with a surface-bound contact active microbial agent. The composition uses silver ion nanoparticles and quaternary ammonium salts, and can be used in coating of implantable medical devices such as urinary catheters and endotracheal tubes.

The covalently bound QAS groups inhibit biofilm formation by microorganisms that come into contact with the coating, such as those present prior to insertion of the device into the body, while the leachable antimicrobial inhibits biofilm formation by microorganisms in the vicinity of the device that do not come into direct contact with the device.

## UV-CURABLE LOW SURFACE ENERGY COATINGS

Radiation-curable chemistry has been instrumental in achieving the industrial regulation goals of zero or low volatile organic content (VOC) coatings. UV-curable coatings have successfully replaced solvent-borne technologies for many applications. Since the coatings are cured by UV radiation, the crosslinking reactions take place at room temperature.

This invention involves the synthesis of novel siloxane-containing unsaturated polyester resins and their UV curing to form coatings having low surface energy. The coatings are useful in applications where low surface energy is desired such as for marine ship hull coatings, anti-graffiti coatings, release coatings, and biocompatible coatings.

The invention relates to the synthesis of siloxane-modified unsaturated polyester oligomers, blending the oligomers with vinyl ethers and a photoinitiator, and curing the formulation to form a coating that has low surface energy.

The curable coating formulation is solvent and water free, and also acrylate-free, eliminating the health hazards associated with acrylates.

RFT 242

## QUATERNARY AMMONIUM FUNCTIONALIZED POSS COMPOUNDS AS ANTI FOULING, ANTI-MICROBIAL AGENT

This invention pertains to the synthesis of quaternary ammonium functionalized POSS compounds (Q-POSS) as anti-fouling, anti-microbial agents in a *two step process*.

These compounds could find applications as contact biocides in liquids (disinfectants to contain microbial growth) and could be incorporated into siloxane network in order to develop anti-fouling anti-microbial coatings with improved mechanical properties.

Antimicrobial activity (Bio-efficacy studies) towards gram-negative (*E.coli*) and gram-positive (*S. aureus*) bacterium has been determined).

RFT 232

## ANTIBACTERIAL SILOXANE POLYMER CONTAINING TETHERED LEVOFLOXACIN

This invention pertains to the development of a polymer material that exhibits superior sustained release of therapeutic levels of the active antibiotic when compared to simple physical bending or doping technologies. The material is prepared by combining a powerful, broad spectrum antibiotic (Levofloxacin), tethered to a siloxane polymer. This invention can potentially be used to coat a variety of biomedically implanted devices for prevention of microbial infection.

RFT 231

## SILOXANE-URETHANE COATINGS FOR ANTI-GRAFFITI AND MARINE ANTIFOULING APPLICATIONS

This invention pertains to novel siloxane-urethane coatings that were developed from unique single-end-functional siloxane polymers. These coatings have novel properties with good adhesion, low surface energy and mechanical strength.

The invention could find its commercial viability in the paint industry in applications related to anti-graffiti and marine antifouling coatings.

## NOVEL COMMERCIAL GRADE HYBRID COATINGS WITH ENHANCED HARDNESS, THERMAL RESISTANCE AND MECHANICAL PROPERTIES

This invention pertains to the preparation of polyurethane-silane hybrid coating systems from glycidyl carbamate resins.

**APPLICATIONS:** In the paint industry as a commercial grade coating and paint product with improved properties.

**PROPERTIES:** This organic-inorganic hybrid coating material shows improved characteristics such as good hardness, better solvency, better abrasion resistance and improved thermal and mechanical properties.

**PREMISE:** Preparation of polyurethane-silane hybrid coating systems from glycidyl carbamate (GC) resin. The invention was conceived with an aim to develop novel hybrid coatings that could possess the reactive properties of epoxy and also have the advantages of carbamate chemistry. Different organic-inorganic hybrid coating materials, using a glycidyl carbamate functional oligomer and amine terminated trimethoxysilane, were prepared by a systematic three-step reaction process. Formation of the Si-O-Si network was performed by moisture curing reactions.

## UNIQUE ANTI-FOULING AND ANTI-MICROBIAL COATINGS FOR MARINE APPLICATIONS

This invention pertains to the development of stable polymeric anti-fouling surface coating formulation that contains Quaternary Ammonium Salts (QAS) as the primary disinfectant.

**APPLICATIONS:** Includes ship hulls, medical devices, and hospital settings.

**PROPERTIES:** Biocidal activities have been shown on a range of bacteria, diatom and yeast cultures. These coatings are found to be stable even after one month of water immersion.

**PREMISE:** The quaternary ammonium salt forms a cross-linked network structure with trimethoxy groups in silanol terminated poly-dimethylsiloxane, where the salt is chemically bonded in the network structure. Types of QASs, their levels of concentration, molecular weight of poly-siloxanes, levels of catalyst, and the amount of cross-linker are the critical determinants on the stability and effectiveness of the coating.

## NON-TOXIC AND DURABLE FOUL RELEASE COATINGS

The adherence of organisms to surfaces exposed to aquatic environments (fouling) is a major economic concern, particularly in the maritime shipping industry. Fouling on ships can increase fuel consumption by up to 40%. Coatings that prevent fouling currently exist but are an environmental concern due to their release of toxic levels of tin and copper.

Scientists at NDSU have invented a novel non-toxic, cross-linked thermoset polysiloxane-polyurethane coating that exhibits properties as foul release (FR) coating and allows organisms to be sloughed off by shear forces obtained at a ship's cruising speed. In addition to exhibiting its fouling release behavior, these coatings have been demonstrated to provide improved durability to its coating surface.

## CONDUCTIVE INK COMPOSITIONS THAT CAN BE HARDENED USING UV RADIATION

This technology is a UV-curable, thermoplastic, conductive ink with zero/near zero amounts of volatile organic compounds (VOCs). The elimination of VOCs in the manufacture of microelectronic devices is highly desired due to costs associated with safety equipment, containment and disposal of compounds.

The inks of this invention are ideally suited for screen printing interconnections and thermally bonding components in microelectronic devices.

## NOVEL ENVIRONMENT FRIENDLY COATINGS FOR MARINE AND MEDICAL APPLICATIONS

This invention pertains to the synthesis of a formulation that has combined biocidal and foul release activities in a single polymeric compound. The formulation is a unique environmentally friendly coating that holds promise in both marine and medical applications. It consists of biocidal moieties that are tethered to its polymer matrix, which in turn prevent them from leaching into the environment.

**APPLICATIONS:** In addition to marine applications, this coating has also been shown to render anti-microbial properties on medical devices.

**PROPERTIES:** The mechanical properties of these coatings are similar to silicone elastomers, yet the coating contains biocidal moieties to deter settlement of organisms. To inhibit leaching of toxic components into the water, biocide moieties are tethered to the polymer matrix.

**PREMISE:** This invention relates to coating formulations based on the modification of moisture cure siloxane elastomers with an alkoxy silane functional polymer containing ammonium salt groups.

## NOVEL "CARRIER GAS" SENSITIZERS FOR IMPROVED LASER ABLATION PERFORMANCE OF COATING FILMS

NDSU inventors have developed polymer films and additives that can be used in polymer films such as polyol photosensitizers, carrier gas UV laser ablation sensitizers and other additives that can be used in preparation of such carrier films.

Laser ablation of polymeric materials results in more precise patterning and improved performance when the polymeric material decomposes into a gas capable of carrying ablation material away (carrier gas).

## UNIQUE COATINGS (WITH PHASE SEPARATION PROPERTIES) FOR USE AS FOUL RELEASE AND ANTI-GRAFFITI PAINTS

This invention pertains to novel coating compositions that spontaneously phase separate to form uniform micro-domains on the coating surface, providing a multiphase topographical surface structure.

**APPLICATIONS:** These coatings may have use as foul release coatings in aquatic environments, anti-graffiti coatings, or as release paper for adhesive labels.

**PROPERTIES:** The micro-domain projections have low adhesion properties which are further augmented by the surface texture that limits the effective surface area for adhesion.

**PREMISE:** Micro-domain projections extrude approximately five microns from the surface with a separation distance of five microns between projections.

## POLYSILOXANE-POLYLACTONE COATINGS WITH ANTI-FOULING PROPERTIES FOR SHIPS AND BOATS

This invention pertains to novel polysiloxane-poly lactone block copolymer compositions that contain carbamate linking groups that are more compatible with polyurethane coatings. These block copolymers are useful for making thermosetting polysiloxane-polyurethane coatings.

These compositions may prove useful in coating formulations to prevent or reduce fouling by marine life and related substances on such surfaces as ship hulls and other exterior surfaces exposed to salt and fresh water.

Coatings utilizing these compounds should significantly reduce the amount of fouling on the exterior of these ships which, in turn, should convey certain advantages such as reduced drag in water with concomitant improvements in performance, e.g., decreased fuel consumption, reduced fleet costs, etc.

Use of these compounds in coatings on the exterior of salt- and fresh-water vessels may result in performance and economic benefits. This technology is of value to those parties involved in paints and coatings for ships and boats.

## HARD, GLOSSY WATER DISPERSIBLE URETHANE EPOXY COATING

This invention pertains to novel water dispersible compositions that have epoxy urethane functional groups. These compounds can be dispersed in water with an added surfactant to form a dispersion containing no volatile organic solvent. The dispersed polymer can self-crosslink and can also crosslink with multifunctional amine compounds into a hard, glossy, solvent resistant coating.

## RADIATION CURABLE SENSITIZERS FOR IMPROVED LASER ABLATION PERFORMANCE OF CROSS-LINKED FILMS

These inventions pertain to unsaturated polyester polymer compositions containing monomer molecules that sensitize the resulting polymer coating/film to ablation (i.e., removal of film material) by exposure to laser radiation (and method for making same). This technology is of potential value to parties in the semiconductor and electronic manufacturing industries.

## NOVEL COATINGS FOR OUTDOOR BRONZES: FEATURES SUPERIOR PROTECTION AND EASY REMOVAL

This invention provides a solution for coating outdoor bronzes that affords both superior protection and easy removal.

**APPLICATIONS:** Outdoor bronze structures: provides protection from salt, UV radiation and moisture (the greatest hazards for outdoor bronzes). It also has potential applications on indoor bronze products.

**PROPERTIES:** Easy application (just spray or brush on the) coating, durability, without yellowing or oxidizing the bronze beneath, Uncomplicated and safe removal and elimination of damage caused by traditional mechanical removal methods.

**PREMISE:** This unique polymer technology has been used (in conjunction with combinatorial chemical methods) to make this coating formulation.

## NOVEL ENVIRONMENT FRIENDLY (CHROMIUM-FREE) PRIMER COATING FOR CORROSION PROTECTION

Since the early 1980's, the use of chromates and other chromium-containing compounds have been subject to stringent regulations due to their recognized carcinogenic properties. This invention is a substitute for widely used chromium-based primer coating products, and is a novel, long lasting, chrome-free primer coating with proven anti-corrosive properties on metals.

This technology has been exclusively licensed in the Aerospace field of use. Licensing opportunities are however available in the other fields of use.

**APPLICATIONS:** This invention has been proven to be the only technology that protects high strength alloys from corrosion, without the need of any chromate pretreatment or pigmentation. Applications of this technology are broad and include aerospace, automobile, air conditioning and medical device manufacturing sectors.

**PROPERTIES:** This technology protects aluminum from corrosion while eliminating toxic and carcinogenic materials, such as chromium, that are currently being predominantly used for corrosion protection.

**PREMISE:** Immersion of elements in an inorganic matrix coating sacrificially corrodes and provides extended corrosion protection to the underlying metal substrate. It alleviates waste disposal hazards. Presence of Mg granulates in the coating provide sacrificial protection to the underlying metal substrate. It alleviates hazardous waste disposal.

## NOVEL ENVIRONMENTAL FRIENDLY COATINGS FOR MARINE APPLICATIONS

Proprietary and novel, silicone-based compounds (and methods for synthesis), some of which incorporate a biocide (for marine applications), have been developed that can be used in coating formulations to prevent or reduce fouling by marine life and related substances on ship surfaces.

**APPLICATIONS:** Includes ship hulls and other surfaces by aquatic organisms.

**PROPERTIES:** Prevent or reduce fouling of ship hulls and other surfaces by aquatic organisms. Some compositions meet certain environmental standards (utilize an approved biocide). The coating exhibits effective anti-fouling properties.

**PREMISE:** The tethered biocide kills organisms that contact coated surfaces and may reduce the incidence of nosocomial infections.

## NEW FAMILY OF ORGANOMETALLIC SINGLE SOURCE PRECURSORS FOR INORGANIC FILMS, COATINGS, AND POWDERS

A new family of organometallic compounds was developed. These compounds contain a metal such as aluminum and a group 16 element such as oxygen in a stoichiometric ratio of 2:3 and can be decomposed to produce an inorganic compound such as Al<sub>2</sub>O<sub>3</sub> (aluminum oxide), eliminating the organic portion of the original compound. Aluminum oxide is the only material developed to date under this program, although it may be expanded to other very useful compounds.

The advantages of the invention include the relatively innocuous nature of the precursor compound and the effluent organic compounds generated during decomposition and the low temperature of decomposition (less than 100°C).

## NOVEL COATING BINDERS COMPRISING LIQUID CRYSTALLINE ENHANCED POLYMERS

Coating compositions comprising liquid crystalline binders are provided by a combination of mesogenic groups and amorphous resins. The mesogenic groups are either covalently bonded or cross-linked to the amorphous resins to provide coatings of exceptional hardness and toughness. Also provided is an economical process suitable for commercial manufacture of mesogenic compounds and more particularly for the production of liquid-crystalline oligoester polyols.

## NOVEL SILOXANE REACTIVE DILUENTS FOR CATIONIC UV COATINGS

This invention revolves around the synthesis of novel siloxane reactive diluents that are compositions of epoxy resins and (cyclo) alkoxy-substituted organosilane.

**APPLICATIONS:** Provides improved properties to coatings that can be used on wood, plastic, paper, or metal. Potential uses include coil coating metal for beer, soda, and other cans, fiber optic protective coatings and microchip coatings or sealants (capsulation).

**PROPERTIES:** The reactive diluent increases the hydrolytic stability of the resultant cured films, and reduces the surface tension of the coatings.

**PREMISE:** This technology has functionalized the polyols with a siloxane group that participates in the film forming reaction via a photolytically initiated cross linking process.

## VEGETABLE SEED-OIL BASED COATING FOR SUPERIOR CORROSION PROTECTION

This vegetable (seed) oil-based (drying oil) coating utilizes mixed metal-oxo clusters to improve the properties of the ceramer films.

**APPLICATIONS:** Has potential uses with roofing materials, corrosion-resistant primers, heavy duty industrial coatings, new generation appliance (alkyd) coatings, and other alkyds or solvent based coatings.

**PROPERTIES:** Environmentally safe technology. The coatings exhibit enhanced hardness without sacrificing toughness, impact resistance, or adhesion. In addition, the mixed metal concept has resulted in films which exhibit superior corrosion protection for metal substrates.

**PREMISE:** Sol-gel methodology is implemented in this invention. The use of two sol-gel precursors has resulted in superior film properties over the use of a single sol-gel precursor.

**FOR FURTHER INFORMATION**

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