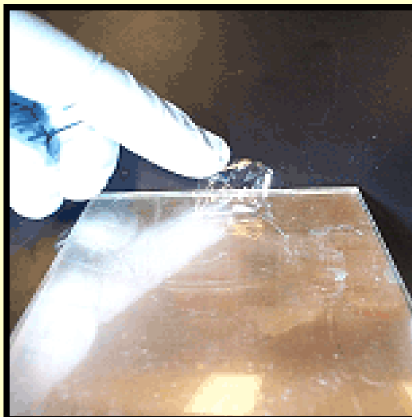
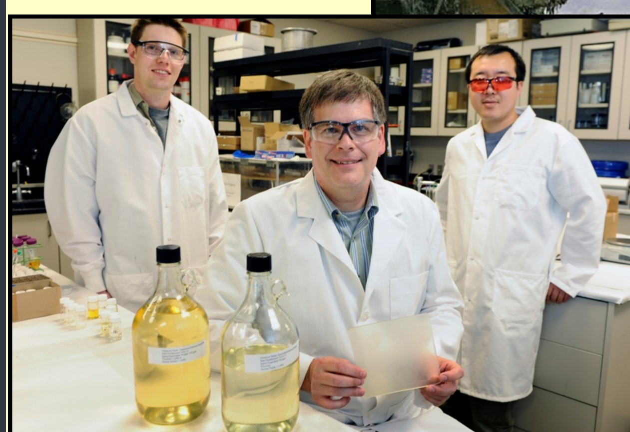
NDSU RESEARCH FOUNDATION

Paints and Coatings Technologies Available for Licensing

Technology



Testing



Discovery

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- General Use
- Biomedical
- Marine
- Anti-Corrosion
- Electronics
- UV-Curable
- Bio-Based
- Anti-Graffiti
- ‘Green’

Paints and Coatings by Application

Tech No.	General Coatings
RFT-530	Photoinitiators that Trigger Extremely Rapid and Efficient Polymer Synthesis Using UV or Visible Light
RFT-529	Renewable and Sustainable Biomass Derived Photodegradable Polymers
RFT-520	Vanillin: A Bio-based Crosslinker for Melamine-Formaldehyde Coatings
RFT-517	Novel Non-Isocyanate Siloxane-Polyurethane Coatings
RFT-512, RFT-513	Modified Soybean Oil Derivatives as Processing Oils for Rubber Compounds
RFT-502, RFT-521	Hard and Flexible, Degradable Thermosets From Renewable Bio-resources with the Assistance of Water and Ethanol
RFT-499	Polymers Derived from Bio-Diesel Waste for Road Dust Control
RFT-490	Acetoacetylated Lignin Thermosets
RFT-488	Bio-based Cyclic Carbonate Functional Resins and Polyurethane Thermosets
RFT-487	Epoxy Resin Thermosets Derived from Vanillin
RFT-459, RFT-489	Bio-based Highly (Meth)Acrylated Resins and Thermosets
RFT-458	Composites from Flax Fibers and Glass Fibers in a Bio-Based Resin
RFT-438	Plant Oil-Based Reactive Diluents for Coating and Composite Applications
RFT-422	Blocked Bio-Based Carboxylic Acids and their Use in Thermosetting Materials
RFT-423	Novel Polymers and Polymeric Materials Based on the Renewable Compounds, Eugenol and Iso-Eugenol
RFT-380	Novel PEGylated Compounds and Process for Making Antifouling/Biocompatible Materials
RFT-365	Bio-Based Toughening Agent for UV-Curable Coatings and Thermoset Polymers
RFT-349	Fast UV-Curing of Anti-Corrosion and Anti-Stain Coatings with High Bio-Based Content
RFT-335	Bio-Based Coatings Based on Monomer-Grafted Alkyd Ester Resins
RFT-318	Polymers Derived from Vegetable Oils Exhibit Increased Crosslink Density, Superior Properties
RFT-314	Bio-Based Functional Resins and Thermoset Materials with Excellent Mechanical Properties
RFT-310	Novel Enamine Compounds and Coating Resins: Miscible Blends of Sucrose Esters
RFT-283	A Polymer for Non-fouling or Fouling Release Type Coatings
RFT-271	Linear Glycidyl Carbamate (GC) Resins for Highly Flexible Coatings
RFT-254	UV-Curable Low Surface Energy Coatings with Fouling Release and Anti-Graffiti Applications
RFT-231	Siloxane-Polyurethane Coatings for Anti-graffiti and Marine Antifouling Applications
RFT-226	Modified Glycidyl Carbamate Resins Exhibiting Superior Mechanical Properties
RFT-225/240	Unique Sol-Gel Hybrid Coatings with Superior Properties for Wide Range of Industrial Applications
RFT-197	Novel Thermoset Siloxane-Urethane Fouling Release Coatings
RFT-158	Unique Coatings with Phase Separation Properties for Use as Foul Release and Anti-Graffiti Paints
RFT-154	Hard, Glossy, Water Dispersible, Urethane, Epoxy Coating
RFT-140	Total Chromium-Free Primer Coating for Corrosion Protection
RFT-118/139	Magnesium Rich Coatings and Coating Systems
RFT-71	Multi-use Aminofunctional Alkoxy Polysiloxanes

Paints and Coatings by Application

Tech No.	Biomedical Paints and Coatings
RFT-380	Novel PEGylated Compounds and Process for Making Antifouling/Biocompatible Materials
RFT-271	Linear Glycidyl Carbamate (GC) Resins for Highly Flexible Coatings
RFT-260	‘Dual Action’ Anti-microbial Coatings for Implantable Medical Devices
RFT-232	Antibacterial Siloxane Polymer Containing Tethered Anti-Microbial Agent
RFT-214	Unique Anti-fouling and Anti-microbial Coatings for Marine Applications
RFT-179	Novel Environment Friendly Coatings for Bio-Medical Applications
RFT-154	Hard, Glossy, Water dispersible, Urethane, Epoxy Coating
RFT-65	A Method of Using Organo-metallic Single Source Precursors to Make Aluminum Oxide or Other Inorganic Coatings
RFT-26	Novel Environmentally Safe Coatings for Ceramer Films Based on Unsaturated Oil

Tech No.	Marine Paints and Coatings
RFT-380	Novel PEGylated Compounds and Process for Making Antifouling/Biocompatible Materials
RFT-319	Novel Amphiphilic Fouling Release Coatings
RFT-283	A Polymer for Non-fouling or Fouling Release Type Coatings
RFT-271	Linear Glycidyl Carbamate (GC) Resins for Highly Flexible Coatings
RFT-254	UV-Curable Low Surface Energy Coatings for Fouling Release and Anti-Graffiti Applications
RFT-231	Novel Siloxane-Polyurethane Coatings for Anti-graffiti and Marine Antifouling Applications
RFT-214	Unique Anti-fouling and Anti-microbial Coatings for Marine Applications
RFT-197	Novel Thermoset Siloxane-Urethane Fouling Release Coatings
RFT-179	Novel Environment Friendly Coatings for Marine and Medical Applications
RFT-158	Unique Coatings with Phase Separation Properties for Use as Foul Release and Anti-Graffiti Paints
RFT-157	Novel Coating Formulations Exhibiting Anti-Fouling Properties for Marine Vessels
RFT-133	Novel Environmental Friendly Coatings for Marine Applications

Tech No.	Anti-Corrosion Paints and Coatings
RFT-509	Smart Coating for Corrosion Mitigation in Metallic Structures
RFT-349	Fast UV-Curing of Anti-Corrosion and Anti-Stain Coatings with High Bio-Based Content
RFT-271	Linear Glycidyl Carbamate (GC) Resins for Highly Flexible Coatings
RFT-219	Novel Polyurethane/Epoxy Hybrid Coatings
RFT-140	Total Chromium-Free Primer Coating for Corrosion Protection
RFT-26	Novel Environmentally Safe Coatings for Ceramer Films Based on Unsaturated Oil

Tech No.	Anti-graffiti Paints and Coatings
RFT-254	UV-Curable Low Surface Energy Coatings with Fouling Release and Anti-Graffiti Applications
RFT-231	Siloxane-Polyurethane Coatings for Anti-graffiti and Marine Antifouling Applications
RFT-158	Unique Coatings with Phase Separation Properties for Use as Foul Release and Anti-Graffiti Paints

Tech No.	UV-Curable Paints and Coatings
RFT-438	Plant Oil-Based Reactive Diluents for Coating and Composite Applications
RFT-365	Bio-based Branched and Hyper-branched UV Curable Oligomers
RFT-349	Fast UV-Curing of Anti-Corrosion and Anti-Stain Coatings with High Bio-Based Content
RFT-335	Bio-Based Coatings Based on Monomer-Grafted Alkyd Ester Resins
RFT-314	Bio-Based Functional Resins and Thermoset Materials with Excellent Mechanical Properties
RFT-254	UV-Curable Low Surface Energy Coatings with Fouling Release and Anti-Graffiti Applications
RFT-197	Novel Thermoset Siloxane-Urethane Fouling Release Coatings
RFT-178	Novel “Carrier Gas” Sensitizers for Improved Laser Ablation Performance of Coating Films
RFT-140	Total Chromium-Free Primer Coating for Corrosion Protection

Tech No.	Electronics Paints and Coatings
RFT-530	Photoinitiators that Trigger Extremely Rapid and Efficient Polymer Synthesis Using UV or Visible Light
RFT-529	Renewable and Sustainable Biomass Derived Photodegradable Polymers
RFT-178	Novel “Carrier Gas” Sensitizers for Improved Laser Ablation Performance of Coating Films
RFT-153	Novel Radiation Curable Sensitizers for Improved Laser Ablation Performance of Cross-linked Films

Tech No.	Green Paints and Coatings NDSU/RF used the term “Green” to refer to a technology that results in a positive
RFT-462	Acrylic Monomers Derived from Plant Oils—Synthesis and Use in High Value Polymers
RFT-438	Plant Oil-Based Reactive Diluents for Coating and Composite Applications
RFT-422	Blocked Bio-Based Carboxylic Acids and their Use in Thermosetting Materials
RFT-365	Bio-Based Toughening Agent for UV-Curable Coatings and Thermoset Polymers
RFT-335	Bio-Based Coatings Based on Monomer-Grafted Alkyd Ester Resins
RFT-318	Polymers Derived from Vegetable Oils Exhibit Increased Crosslink Density, Superior Properties
RFT-314	Bio-Based Functional Resins and Thermoset Materials with Excellent Mechanical Properties
RFT-179	Novel Environment Friendly Coatings for Bio-Medical Applications
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RFT-133	Novel Environmental Friendly Coatings for Marine Applications
RFT-26	Novel Environmentally Safe Coatings for Ceramer Films Based on Unsaturated Oil

Tech No.	Bio-based Paints and Coatings
RFT-520	Vanillin: A Bio-based Crosslinker for Melamine-Formaldehyde Coatings
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RFT-512, RFT-513	Modified Soybean Oil Derivatives as Processing Oils for Rubber Compounds
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RFT-499	Polymers Derived from Bio-Diesel Waste for Road Dust Control
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RFT-314	Bio-Based Functional Resins and Thermoset Materials with Excellent Mechanical Properties

Tech. No.	Technology Title	Category(ies)
RFT-530	**Photoinitiators that Trigger Extremely Rapid and Efficient Polymer Synthesis Using UV or Visible Light** NDSU researchers have developed a range of Type I, Type II, and acidic photoinitiators, which provide polymerization of polyacrylate with good efficiency at low concentrations. The synthesis of photoinitiators is efficient using routine chemistry, and their structures are easily manipulated to tune for low energy (including visible) light wavelengths. These photoinitiators are each triggered by a very narrow and easily defined wavelength, making timing of polymerization easy to control (and avoiding inadvertent triggering of the reaction). The photoinitiators may be produced from either bio-based or petroleum-based starting materials, including such readily available materials as vanillin.	**General** **Electronics**
RFT-529	**Renewable and Sustainable Biomass Derived Photodegradable Polymers** Worldwide efforts have been devoted to converting biomass into chemicals due to the high abundance, low cost, and renewability. Carbohydrates are of particular interest as one of its derivatives, FDCA, is one of the top 14 bio-based chemicals that can be used as a replacement in the synthesis of polyethylene terephthalate (PET). Though made from renewable resources, recyclability of the polymers has remained an issue. Sivaguru et al addressed this through the use of a nitrobenzyl phototrigger unit backbone which allows for controlled photodegradation, via UV irradiation, of biomass-derived polymers.	**General** **Electronics**
RFT-520	**Vanillin: A Bio-based Crosslinker for Melamine-Formaldehyde Coatings** In an effort to improve environmental bio-compatibility, bio-based materials have been explored as alternatives to petrochemical-based composites. Specifically, there is currently an unmet need in the field for bio-based aromatic compounds. Lignin is the most abundant aromatic biopolymer with excellent thermal and mechanical properties. One of its degradation products, vanillin, is considered a waste product in pulp and paper industries making it cost-effective as a building block for polymers. Webster et al have synthesized a novel phenolc resin based on vanillin and then crosslinked the resin with melamine-formaldehyde (MF) resins which have numerous applications such as laminate flooring, cabinetry, surface coatings, textile finishes, and paper processing. They developed a novel synthetic approach resulting in various resins and coating compositions in which vanillin significantly increased impact, hardness, and solvent resistance.	**General** **Bio-Based**
RFT-517	**Novel Non-Isocyanate Siloxane-Polyurethane Coatings** Glycidyl carbamate (GC) functional resins are used due to their high mechanical strength, toughness and abrasion and chemical resistance associated with polyurethanes as well as the convenience of epoxy-amine chemistry. Webster et al. have combined these resins with polydimethylsiloxane to develop self-stratified coatings that yield coatings hav ing low surface energy as well as reduce the hazards of isocyanates.	**General** **Bio-Based**
RFT-512 RFT-513	**Modified Soybean Oil Derivatives as Processing Oils for Rubber Compounds** There has been growing commercial and industrial interest in biodegradable and renewable materials over petroleum-based materials. Particularly, soybean oil is widely used due to its availability and low cost. Chisholm et al have determined that appropriate modification of soybean oil results in materials for use as a processing oil for rubber compounds. They show, through numerous examples, that the use of unmodified soybean oil reduces key mechanical properties, such as moduli and tensile strength when compared to conventional petroleum-based processing oils. However, rheological and mechanical properties can be substantially improved by 1) styrenating the soybean oil or 2) producing a higher molecular weight liquid from soybean oil (ex: sucrose soyate and soy-based oligomer). Thus, soybean oil can be used as the basis for a bio-based and green alternative to petroleum-based oils for rubber compounds.	**General** **Bio-Based**

Tech. No.	Technology Title	Category(ies)
RFT-509	**Smart Coating for Corrosion Mitigation in Metallic Structures** Though corrosion is well understood in terms of mechanisms and methods of control, it still accounts for a notable number of failures in pipelines buried or on the ground. This is due to a large number of potential complications such as varying soil properties along the pipeline and over time, local cracks on the soft coating surface, separation of coating from the pipeline surface, and corrosive environments. To address this, Azarmi et al developed smart coatings which can both prevent and monitor corrosion of steel through the use of a hard coating deposited by thermal spraying with embedded Fiber Bragg Grating (FBG) sensors.	Anti-Corrosion Paints and Coatings
RFT-502 RFT-521	**Hard and Flexible, Degradable Thermosets from Renewable Bioresources with the Assistance of Water and Ethanol** Thermosets are widely used in industry due to their superior dimensional stability, good processing ability, and high formulation flexibility for tailoring the desired properties such as high modulus, strength, durability, and thermal and chemical resistance. However, they may release VOCs, cannot be reprocessed by heat or solvent, and depend on non-renewable resources. To address these issues, Webster et al. developed degradable bio-based thermosets. These novel thermosets achieve high hardness while maintaining excellent flexibility as well as outstanding adhesion and solvent resistance, which is unprecedented in the field. Further, they degrade rapidly in aqueous base conditions in addition to being thermally degradable.	General Bio-Based
RFT-499	**Polymers Derived from Bio-Diesel Waste for Road Dust Control** Scientists at NDSU have developed a new material that can be applied to gravel roads for suppression of road dust. The material is made from the huge waste stream that is generated during the production of biodiesel which is primarily glycerol and biodegradable or bio-derived fatty acid esters. The new material is made up of mono- and di-gylcerides that are synthesized from a combination of waste glycerol and soybean oil triglycerides. Upon application to the road surface, the glycerides undergo crosslinking reactions to form a larger, more stable molecule.	General Bio-Based
RFT-490	**Acetoacetylated Lignin Thermosets** Lignin is a key component of woody plants, the most abundant aromatic bio-polymer in nature, and is made up of a mixture of aromatic alcohols, the monolignols, as opposed to carbohydrate monomers. Commercially, lignin is sourced from wood products and is a direct byproduct of the pulping process to convert wood into wood pulp and extract cellulose. However, it is currently treated as a waste product which limits its use. Webster et al have identified another use through the acetoacetylation of lignin to develop bio-based resins. The lignin can be used directly from the pulping process or be depolymerized first and is an excellent source of terrestrial carbon that can be developed into thermoplastic and thermosetting polymers. Acetoacetylation of lignin results in a resinous liquid.	General Bio-Based

Tech. No.	Technology Title	Category(ies)
RFT-488	**Bio-based Cyclic Carbonate Functional Resins and Polyurethane Thermosets** There has been growing interest in bio-based resins due to the foreseeable limit of fossil feedstocks and increasing environmental concern. Additionally, polyurethanes are widely used commercially but rely on petroleum-based materials and utilize isocyanate, which is hazardous. Webster et al. have developed a novel bio-based material that can be reacted with amines to form polyurethanes using a non-isocyanate route, and thus are safer than current systems. Specifically, the resins contain a high number of cyclic carbonate groups synthesized from the reaction of epoxidized sucrose fatty acid ester resin with carbon dioxide. Further, these resins are prepared from epoxidized sucrose fatty acid esters from different vegetable oils and can be fully or partially carbonylated.	**General** **Bio-Based**
RFT-487	**Epoxy Resin Thermosets Derived from Vanillin** Thermosetting polymers and composites are widely used in industry due to their low density, good mechanical properties, low cost, and dimensional stability. However, most resins are synthesized primarily using petroleum-based chemicals. Due to current environmental concerns and the limit of fossil feedstocks, the industry is suffering from increasing costs and environmental regulations. Webster et al. have developed novel epoxy resins synthesized from the reaction between vanillin and diamines to form a Schiff base. Vanillin can also be glycidated to form another bio-based resin. Vanillin is derived from the depolymerization of lignin, an abundant aromatic bio-polymer currently treated as a waste product in pulp and paper industries, and therefore expands the use of traditionally wasted materials.	**General** **Bio-Based**
RFT-462	**Acrylic Monomers Derived from Plant Oils - Synthesis and Use in High Value Polymers** Scientists at NDSU have developed a one-step method to convert plant oil into acrylic monomers that substitute for petroleum-based monomers in the production of acrylic polymers. This method can use essentially any plant oil, animal fat, or other fatty esters as the raw material. The output is a combination of (meth) acrylic fatty monomers that can be used directly in the production of latexes, adhesives, surfactants, sizing agents, resins, binders, and other products that utilize acrylic polymers. Additionally, the NDSU monomers contain two types of double bonds. The one within the acrylic group is reactive in conventional addition free radical polymerization, which allows formation of linear polymers. The double bonds within the fatty chain remain unaffected during free radical polymerization, so remain available for oxidative cross-linking and additional tuning of the polymer performance characteristics. This is in contrast to existing plant oil based monomers, which produce non-linear branched and cross-linked polymers (because their fatty chain double bonds participate in the polymerization) The performance attributes of the linear structure derived from the NDSU monomers provide significant benefits as compared with competing plant oil based polymers, with far more options for tuning their functionality and controlling their performance because of their great versatility in macromolecular configuration and chemical composition.	**Bio-Based** **Green**
RFT-459 **RFT-489**	**Bio-Based Highly (Meth)Acrylated Resins and Thermosets** Thermosetting polymers and composites are widely used in industry due to their many desirable characteristics, such as low density and cost, dimensional stability, and good mechanical properties. However, most of these resins are petroleum-based raising environmental concerns and potentially increasing cost and regulations. Thus, there is a demand for novel resins and composites synthesized from renewable materials, such as plant oils. Webster et al. answer that need with a novel bio-based resin containing a large number of unsaturated vinyl groups. Specifically, they have developed a polyfunctional bio-based oligomer synthesized from an epoxidized sucrose fatty acid ester resin and an ethylenically unsaturated ester (RFT-459). More recent modifications by the group (RFT-489) have added an acid anhydride leading to a vinyl functionalized resin with a lower viscosity. The resins can then be cured using free radical initiators to form highly crosslinked thermosets with numerous applications. These systems use significantly lower amounts of styrene than petrochemical vinyl ester resins.	**General** **Bio-Based**

Tech. No.	Technology Title	Category(ies)
RFT-458	**Composites from Flax Fibers and Glass Fibers in a Bio-Based Resin** The use of bio-based resins and/or natural fibers in composites has emerged due to the need for improved chemical sustainability and environmental impact. There is growing interest in polyurethanes as they are durable and cost effective. However, they are traditionally made from petroleum based polyols and isocyanates. Ulven et al answer the need for sustainable materials with the development of structural biocomposites comprising cellulose-based bast natural fibers and/or glass fibers and bio-based polyurethanes. Specifically, bio-based polyols are reacted with polyisocyanates to generate bio-based polyurethanes. These materials have a higher modulus, hardness, and Tg than other bio-based and petroleum-based polyols.	**General** **Bio-Based**
RFT-438	**Plant Oil-Based Reactive Diluents for Coating and Composite Applications** NDSU scientists have developed plant oil-based reactive diluents for coating and composite applications that possess both low viscosity and high reactive functionality. With these improved characteristics, these plant oil-based materials eliminate or reduce the need to be blended with petrochemicals thereby increasing the bio-based content of the product, which is environmentally more desirable. The fundamental aspect of the invention involves transesterification of a plant oil triglyceride with an alcohol that also contains at least one double bond. By completely replacing the glycerol component of the plant oil triglyceride with three equivalents of the unsaturated alcohol, fatty acids esters are produced containing at least one double bond that is not derived from the parent plant oil. Depending on the application requirements, a low-cost, biobased unsaturated alcohol can be used to produce the reactive diluents of the invention.	**General** **UV Curable** **Bio-Based** **Green**
RFT-423	**Novel Polymers and Polymeric Materials Based on the Renewable Compounds, Eugenol and Iso-Eugenol** Due to the finite supply of fossil resources and the growing environmental concern, there is a major need for chemicals and materials derived from renewable resources. Aromatic building blocks, such as phenols, are particularly important and can be derived from renewable sources. Chisholm et al are the first to convert eugenol and iso-eugenol into vinyl ether monomers via reaction of the hydroxyl group. The result is soluble, processable linear polymers that retain the allyl group for crosslinking reactions and incorporation of other functional groups.	**General** **Bio-Based**
RFT-422	**Blocked Bio-Based Carboxylic Acids and Their Use in Thermosetting Materials** Scientists working at NDSU have discovered a way to make vinyl-block bio-based carboxylic acid crosslinkers for epoxy resins that are particularly useful for vegetable oil based epoxy resins. The resulting coatings have an excellent combination of hardness, flexibility, adhesion, and solvent resistance.	**General** **Bio-Based** **Green**

Tech. No.	Technology Title	Category(ies)
RFT-365	**Bio-Based Toughening Agent for UV-Curable Coatings and Thermoset Polymers** Scientists working at NDSU have developed branched and hyperbranched oligomers derived from a combination of soybean and cashew nutshell oils (CNSL). These oligomers can be either UV-cured (for coatings) or thermally cured (to produce thermoset polymers). Coatings incorporating this hyperbranched material had improved adhesion and impact resistance, because the coatings were both strong and flexible. This material can be used in anti-corrosion coatings and sealants, composites, inks, and adhesives, as well as directly in thermoset polymers. These oligomers impart improved material properties compared to current bio-based materials, and in some cases exhibit properties superior to even their petroleum-based counterparts.	**General** **UV-Curable** **Bio-Based** **Green**
RFT-349	**Fast UV-Curing of Anti-Corrosion and Anti-Stain Coatings with High Bio-Based Content** NDSU Scientists have developed a UV-curable anti-corrosion coating for metal and wood substrates. The coating is curable in 30 to 60 seconds at room temperature under UV light. Coating components include well-known materials, including a UV-responsive photoinitiators, acrylated plant oil (providing hydrophobicity and contributing to physical barrier), and hyperbranched polyester (providing physical barrier to moisture). Variations on this basic formula can be developed and optimized for specific substrates and environmental conditions to create highly functional anti-corrosion coatings with a high bio-based content.	**General** **UV-Curable** **Bio-Based** **Anti-Corrosion** **Green**
RFT-335	**Bio-Based Coatings Based on Monomer-Grafted Alkyd Ester Resins** Scientists at NDSU have synthesized monomer-grafted sucrose ester resins by polymerizing styrene in the presence of the sucrose ester resins. At a composition of 50% styrene-50% sucrose ester, coatings had extremely fast track free drying times, similar to a commercial styrenated alkyd resin. However, the styrenated sucrose ester resin had a much lower viscosity than the commercial resin, meaning that higher solids coatings can be prepared. In addition, water dispersible resins were prepared by grafting a mixture of styrene and acrylic acid with the sucrose ester resin. These could be cross-linked with a melamine-formaldehyde resin to yield coatings that had good hardness, adhesion, and flexibility.	**General** **UV-Curable** **Bio-Based** **Green**
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 inturn demonstrate a syngerist 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.	**Marine**

Tech. No.	Technology Title	Category(ies)
RFT-318	**Polymers Derived from Vegetable Oils Exhibit Increased Crosslink Density, Superior 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 conversional 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.	**General** **Green**
RFT-314	**Bio-Based Functional Resins and Thermoset Materials with Excellent Mechanical Properties** NDSU Scientists have synthesized highly functional epoxy resins from the epoxidation of vegetable oil esters of polyols having 4 hydroxyl groups per molecule. These epoxy resins can be cured using UV photo-initiators into hard coatings. The novel epoxy resins can also be incorporated into formulations containing oxetanes, cycloaliphatic epoxies, and polyols. The photo-polymerization rate is significantly higher for these novel epoxy resins when compared to conventional epoxidized vegetable oil.	**General** **Bio-Based** **UV-Curable** **Green**
RFT-310	**Novel Enamine Compounds and Coating Resins: Miscible Blends of Sucrose Esters** Novel enamine compounds have been made from acetoacetylated polyols and monofunctional amines. In addition, novel compounds containing both esters of carboxylic acids and acetoaceate groups have also been synthesized. Coatings are also made which are cured by a combination of enamine formation through polyfunctional amines and through autoxidation of the vegetable oil moities.	**General**
RFT-283	**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.	**General** **Marine**
RFT-271	**Linear Glycidyl Carbamate (GC) Resins for Highly Flexible Coatings** Scientists at North Dakota State University have invented a Low-VOC, chromate-free, solvent-borne, low viscosity, highly flexible coating resin system. This resin system has the functionality of an epoxy resin while providing the performance of a polyurethane coating without exposing the end-user to isocyanates. When crosslinked with amines, these GC coatings have excellent adhesion, hardness, solvent resistance, gloss, and flexibility on cold-rolled steel and aluminum substrates. This polymer technology was specifically developed to be used to obtain highly flexible coatings while maintaining good solvent and chemical resistance.	**Biomedical** **Marine** **Anti-corrosion**
RFT-260	**'Dual Action' Anti-microbial Coatings for Implantable Medical Devices** This invention pertains to 'dual action' anti-microbial polysiloxane coatings having a leachable anti-microbial agent in conjunction with a surface-bound contact active microbial agent. The composition uses silver ion nanoparticles and quaternary ammonium salts, and can be use 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 anti-microbial inhibits biofilm formation by microorganisms in the vicinity of the device that do not come into direct contact with the device.	**Biomedical**

Tech. No.	Technology Title	Category(ies)
RFT-254	**UV-Curable Low Surface Energy Coatings with Fouling Release and Anti-Graffiti Applications** 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.	**General** **Marine** **UV-Curable** **Anti-Graffiti**
RFT-232	**Antibacterial Siloxane Polymer Containing Tethered Anti-Microbial Agent** 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.	**Biomedical**
RFT-231	**Novel Siloxane-Polyurethane Coatings for Anti-fouling 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 anti-fouling coatings.	**General** **Marine** **Anti-Graffiti**
RFT-226	**Modified Glycidyl Carbamate Resins Exhibiting Superior Mechanical Properties** This invention pertains to novel glycidyl carbamate resins that have been modified with alkyl or ether alkyl groups. These resins have improved properties such as lower viscosity, which makes them good candidates for commercialization in the paint industry. In particular, it has potential for application as a coating on aircrafts.	**General**
RFT-225/240	**Unique Sol-Gel Hybrid Coatings with Superior Properties for Wide Range of Industrial Applications** This invention pertains to the preparation of polyurethane-silane hybrid coating systems from glycidyl carbamate resins. 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.	**General**
RFT-219	**Novel Polyurethane/Epoxy Hybrid Coatings** This invention involves the preparation of a novel coating composition comprising a glycidyl carbamate functional resin, an aromatic epoxy resin, and a polyamine cross-linker. This coating formulation with the aromatic epoxy resin has improved corrosion resistance over coatings that do not contain the aromatic epoxy resin.	**Anti-Corrosion**

Tech. No.	Technology Title	Category(ies)
RFT-214	**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 quarternary 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.	**Marine** **Biomedical**
RFT-197	**Novel Thermoset Siloxane-Urethane Fouling 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.	**General** **Marine** **UV-Curable**
RFT-179	**Novel Environment Friendly Coatings for Bio-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 alkoxysilane functional polymer containing ammonium salt groups.	**Marine** **Biomedical** **Green**
RFT-178	**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 photosensitizes, 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).	**Electronics** **UV-Curable**

Tech. No.	Technology Title	Category(ies)
RFT-158	**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 sur-	General Marine Anti-Graffiti
RFT-157	**Novel Coating Formulations Exhibiting Anti-Fouling Properties for Marine Vessels** This invention pertains to novel polysiloxane-polylactone 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.	Marine
RFT-154	**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. **STATUS:** **Optioned in “Biomedical Coating Application on Medical Devices” Field of Use** **Available in All Other Fields**	General Biomedical
RFT-153	**Novel 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 semi-conductor and electronic manufacturing industries.	Electronics
RFT-140	**Total 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. In an attempt to find a substitute for widely used chromium-based primer coating products, scientists at North Dakota State University have invented a novel, chrome–free primer coating with proven anti-corrosive properties on metal substrates The use of this primer eliminates risks associated with handling toxic and carcinogenic chromium metallic compounds, and alleviates waste disposal hazards. This invention has been proven to be the only technology that protects high strength Aluminum alloys from corrosion, without the need of any chromate pretreatment or pigmentation.	General Anti-corrosion Green

Tech. No.	Technology Title	Category(ies)
RFT-133	**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. This technology prevents or reduces 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. The tethered biocide kills organisms that contact coated surfaces and may reduce the incidence of nosocomial infections.	Marine Green
RFT-118/139	**Magnesium Rich Coatings and Systems** This technology package consists of two different disclosures. One is a protective primer coating for two different aluminum alloys used in the construction of aircraft. The second is the application and optimization of that coating to structures of different alloys such as aircraft skin, rivets and struts. This technology protects aluminum from corrosion while eliminating toxic and carcinogenic materials such as chromium, that are currently used for corrosion protection.	General
RFT-71	**Multi-use Aminofunctional Alkoxy Polysiloxanes** This invention involves the method of preparing aminofunctional polysiloxanes. The method includes reacting a polyhydrosiloxane with an alcohol reactant including an aminoalcohol to form the aminofunctional alkoxy polysiloxane. The reaction is typically carried out in the presence of a catalyst which includes a rhodium compound. The invention also describes a coating composition which inludes an aminofunctional alkoxy polysiloxane. The coating composition is particularly suitable as an adhesive or primer for coupling a topcoat to a substrate.	General
RFT-65	**A Method of Using Organometallic Single Source Precursors to Make Aluminum Oxide or Other Inorganic Coatings** 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 A1203 (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^{o}C).	General
RFT-26	**Novel Environmentally Safe Coatings for Ceramer Films Based on Unsaturated Oil** This vegetable (seed) oil-based (drying oil) coating utilizes mixed metal-oxo clusters to improve the properties of the ceramer films. This Technology 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. 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.	General Anti-corrosion Green

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