# Framework Title

Organization: Lawrence Hall of Science
Contact person: Frank Kusiak
Contact information: frank_kusiak@berkeley.edu

## General Description

**Audience:**
Designed for a general audience of science museum visitors. Families and kids who can draw (3 and up).

**Type of program:**
Oleophobic Surfaces is a hands on cart demonstration for spontaneous, 3-10 minute interactions with visitors. The visitors will explore several surfaces that display oleophobic properties due to material science research at the nano scale.

## Program Objectives

**Learning Objectives:**
**Oleophobic means "Oil hating"**
Visitors will learn that:

- Materials science has created oleophobic surfaces using nanomaterials.
- Oleophobic surfaces have many applications like in anti-graffiti coatings, lenses/electronic touch displays, and pipes that move oils efficiently.
- If the surface is properly coated, a liquid's ability to adhere to itself may be greater than its ability to adhere to the surface.

**NISE Network content map main ideas:**

[x] 1. Nanometer-sized things are very small, and often behave differently than larger things do.

[x] 2. Scientists and engineers have formed the interdisciplinary field of nanotechnology by investigating properties and manipulating matter at the nanoscale.

[x] 3. Nanoscience, nanotechnology, and nanoengineering lead to new knowledge and innovations that weren't possible before.

[ ] 4. Nanotechnologies have costs, risks, and benefits that affect our lives in ways we cannot always predict.

[Place an "x" in the brackets above to indicate big ideas covered in the program.]

## National Science Education Standards:

[ ] 1. Science as Inquiry
- [ ] K-4: Abilities necessary to do scientific inquiry
- [ ] K-4: Understanding about scientific inquiry
- [ ] 5-8: Abilities necessary to do scientific inquiry
- [ ] 5-8: Understanding about scientific inquiry
- [ ] 9-12: Abilities necessary to do scientific inquiry
- [ ] 9-12: Understanding about scientific inquiry

[ ] 2. Physical Science
- [ x ] K-4: Properties of objects and materials
- [ ] K-4: Position and motion of objects
- [ ] K-4: Light, heat, electricity, and magnetism
- [x] 5-8: Properties and changes of properties in matter
- [ ] 5-8: Motions and forces
- [ ] 5-8: Transfer of energy
- [ ] 9-12: Structure of atoms
- [ x ] 9-12: Structure and properties of matter
- [ ] 9-12: Chemical reactions
- [ ] 9-12: Motions and force
- [ ] 9-12: Conservation of energy and increase in disorder
- [ ] 9-12: Interactions of energy and matter

[ ] 3. Life Science
- [ ] K-4: Characteristics of organisms
- [ ] K-4: Life cycles of organisms
- [ ] K-4: Organisms and environments
- [ ] 5-8: Structure and function in living systems
- [ ] 5-8: Reproduction and heredity
- [ ] 5-8: Regulation and behavior
- [ ] 5-8: Populations and ecosystems
- [ ] 5-8: Diversity and adaptations of organisms
- [ ] 9-12: The cell
- [ ] 9-12: Molecular basis of heredity
- [ ] 9-12: Biological evolution
- [ ] 9-12: Interdependence of organisms
- [ ] 9-12: Matter, energy, and organization in living systems
- [ ] 9-12: Behavior of organisms

[ ] 4. Earth and Space Science
- [ ] K-4: Properties of earth materials
- [ ] K-4: Objects in the sky
- [ ] K-4: Changes in earth and sky
- [ ] 5-8: Structure of the earth system
- [ ] 5-8: Earth's history
- [ ] 5-8: Earth in the solar system
- [ ] 9-12: Energy in the earth system

[ ] 9-12: Geochemical cycles
[ ] 9-12: Origin and evolution of the earth system
[ ] 9-12: Origin and evolution of the universe

[ ] 5. Science and Technology
[ ] K-4: Abilities to distinguish between natural objects and objects made by humans
[ x ] K-4: Abilities of technological design
[ x ] K-4: Understanding about science and technology
[ x ] 5-8: Abilities of technological design
[ x ] 5-8: Understanding about science and technology
[ ] 9-12: Abilities of technological design
[ ] 9-12: Understanding about science and technology

[ ] 6. Personal and Social Perspectives
[ ] K-4: Personal health
[ ] K-4: Characteristics and changes in populations
[ ] K-4: Types of resources
[ ] K-4: Changes in environments
[ x ] K-4: Science and technology in local challenges
[ ] 5-8: Personal health
[ ] 5-8: Populations, resources, and environments
[ ] 5-8: Natural hazards
[ ] 5-8: Risks and benefits
[ x ] 5-8: Science and technology in society
[ ] 9-12: Personal and community health
[ ] 9-12: Population growth
[ ] 9-12: Natural resources
[ ] 9-12: Environmental quality
[ ] 9-12: Natural and human-induced hazards
[ x ] 9-12: Science and technology in local, national, and global challenges

[ ] 7. History and Nature of Science
[ x ] K-4: Science as a human endeavor
[ x ] 5-8: Science as a human endeavor
[ ] 5-8: Nature of science
[ ] 5-8: History of science
[ ] 9-12: Science as a human endeavor
[ ] 9-12: Nature of scientific knowledge
[ ] 9-12: Historical perspective

[Place an “x” in the brackets above to indicate standards covered in the program.]

## Table of Contents

## Background Information

### Definition of terms

Nano is the scientific term meaning one-billionth (1/1,000,000,000). It comes from a Greek word meaning “dwarf.”

A nanometer is one one-billionth of a meter. One inch equals 25.4 million nanometers. A sheet of paper is about 100,000 nanometers thick. A human hair measures roughly 50,000 to 100,000 nanometers across. Your fingernails grow one nanometer every second.

(Other units can also be divided by one billion. A single blink of an eye is about one-billionth of a year. An eyeblink is to a year what a nanometer is to a yardstick.)

Nanoscale refers to measurements of 1-100 nanometers. A virus is about 70 nm long. A cell membrane is about 9 nm thick. Ten hydrogen atoms are about 1 nm.

At the nanoscale, many common materials exhibit unusual properties, such as remarkably lower resistance to electricity, or faster chemical reactions.

Nanotechnology is the manipulation of material at the nanoscale to take advantage of these properties. This often means working with individual molecules.

Nanoscience, nanoengineering and other such terms refer to those activities applied to the nanoscale. “Nano,” by itself, is often used as short-hand to refer to any or all of these activities.

Hydrophobic: A surface that repels water. A super hydrophobic surface can force water to form a bead (a drop of water with a high contact angle) and roll off.

Interface: where two or more materials meet and interact.

Oleophobic: An “oil hating” surface. It’s a surface that has a material or landscape that’s “low energy” allowing liquids with low surface tension to either bead and/or easily move over the surface.

Low energy surface: A material’s surface can be considered high energy (the bonds between the material’s atoms are strong like in untreated cement, wood, or metal) and low energy where the bonds are weaker. When a liquid comes into contact with a surface and the liquid’s molecules attraction to each other (surface tension) exceeds the liquid’s attraction to the surface, the surface can be considered to have a low energy surface relative to the liquid.

Contact Angle: An angle that can be measured where the liquid, a solid surface, and gas intersect (a liquid/solid/gas interface). A low contact angle means that liquid is spreading out and is attracted to the surface material (zero degrees means it’s flush with the surface). A high contact angle means that the liquid is not spreading out, but instead, balling up like water on a super-hydrophobic surface (In such cases, water will have a contact angle greater than 150 degrees!).

## Program-specific background

Oleophobic surfaces repel oil and many other low, surface tension liquids like alcohol. Probably the most well known oleophobic surface is the iPhone's/iPad's touch screen. Super-oleophobic surfaces don't occur in nature when you have a solid, liquid, and gas interface (For example, you're outside, you drop oil on a rock. The oil (liquid) on the rock (solid) is probably naturally spreading out, and air (gas) does not come between the oil and rock). Although hard to imagine, there are super-oleophobic surfaces that occur naturally underwater. On shark skin or fish scales, oil will bead up. Why? It prevents other organisms from adhering/fouling the shark or fish; you won't see a shark with barnacles! In such cases, the interface is between a solid (shark skin), and two liquids; oil and water. (Anish Tuteja, Wonjae Choi, Gareth H. McKinley, Robert E. Cohen, and Michael F. Rubner, "Design Parameters for Superhydrophobicity and Superoleophobicity " MRS Bulletin, Vol 33, August 2008 And http://www.beilstein-journals.org/bjnano/single/articleFullText.htm?publicId=2190-4286-2-9)

An oleophobic surface is created when a material's surface energy is lower than the oil's surface tension. An anti-graffiti surface should be both oleophobic and hydrophobic; as most paints and inks are made with oil, water, or alcohol bases. Naturally, a good anti-graffiti coating should be able to repel these liquids. Material scientists have a way (usually proprietary) of attaching an oleophobic or hydrophobic molecule or "tail" to nanoparticles (silica in most cases) inside of the polymer based coating. The tails that stick out create our hydrophobic/ oleophobic, low energy surface.

Anti-graffiti coatings can be sacrificial (they come off with the graffiti), semi-sacrificial (only part of it comes off with the graffiti leaving some coatings behind), and permanent. The anti-graffiti in both the Aculon lens and Seicoat GPA 300 are supposed to be permanent (but from experience, the Seicoat eventually does wear out).

Information about the products:

The Anti-Graffiti Coating from Seicoat is a polymer infused with nano particles of silicon. The exact formula is proprietary. It creates a surface that's both oleophobic and slightly hydrophobic. (http://www.seicoat.com/graffitiGPA300.html)

The treated side of the Aculon lens is created in a controlled environment and the proprietary coating is nanometers thin (3-4 nm). (http://www.aculon.com/oleophobic-coatings.php)

Sharpie ink is alcohol based. Alcohol also has low surface tension, and so it'll behave like other low surface tension liquids (like oil) on the anti-graffiti/oleophobic surface. If you notice, the Sharpie's ink beads up on the anti-graffiti surface much like an oil-based paint will.

## Cart Demo Short Description

Visitors will explore what oleophobicity means by interacting with several materials that display oleophobic properties. They'll dip a lens (where one half is treated with an oleophobic material) into oil and see how the oil easily slides off the treated side, and reluctantly slides of the other. After introducing this concept, they'll also graffiti a metal shingle: one treated with an oleophobic/anti-graffiti coating and the other is untreated. We will also challenge our visitors to think of other applications for oleophobic surfaces.

## Materials

Oleophobic Lens Activity:

- A treated sample lens from Aculon (free upon request at aculon.com)
- A clear cup to place a 3" lens in (either vertically or horizontally)
- Oil (vegetable, olive, canola, etc)
- Paper towels (for clean up)

Anti-Graffiti Metal Substrate

- 2 Metal Shingles – one treated, one untreated (Prep Notes later)
- Sharpies of various colors
- Paper towels
- Water (for cleaning)
- Rubbing alcohol (for cleaning Sharpie from the untreated metal)

Note: Find graffiti proofer here: http://www.seichemical.com/products.php?cat=7
Also: a waste liquid container and trash can if you're going to do this activity for an extended period of time.

## Set Up

**Time:**
5 minutes

Follow the step-by-step explanation of how to prepare for each of the activities provided in the activity guides or lesson plans.
Setup is straight-forward. You can change the sequence with which you do these activities. Basically, place the first activity in front of you, and the others off to the side.

1) Pour your oil in a clear cup.
2) Place the lens and clear cup in to one side of you.

3) Place the small pouring containers and cups  to one side (which ever you're comfortable with and you can manage, it doesn't matter if you place them on the same side or opposite side of the other activity)
4) Place the treated and untreated shingle in front of you along with the Sharpies.
5) Make sure the paper towels, water, and alcohol wipes are within reach.
6) If you have a sign, place it in a visible place on the table.

## Program Delivery

### Safety

- If you're using metal shingles, please be careful of pointy edges.  Make sure the corners are rounded.
- Also, keep the shingles on the table as they can be very thin and hard.  Have an adult handle or closely supervise a responsible kid if they want to pick one up.
- Alcohol is flammable.  Please use caution when handling it, and keep it away from the visitors.
- If oil is spilled on a smooth surface made for walking, clean it up immediately!
- Don't let the kids sniff the Sharpies.

### Talking points and outline

1. Invite visitors to graffiti your metal shingles.  Give them various colors of Sharpie, and let them be creative.  Of course, one of the shingles will behave differently. (You may need to be careful that a kid doesn't wipe ink on their sleeves as they're drawing.)
2. Have the kids stop drawing and see if they can spot the difference between the two drawings (it also lets the untreated side dry).
3. Wipe the treated and untreated board with a wet paper towel.  The untreated side's ink should still be there while the treated side should clean up. (It's best to dab the treated side.)
4. Why is this!?  Let's try it again.
5. Hmmm….I don't know!!
6. Keep this question up in the air.  Move onto the Oleophobic lens.  "Ok, now I have a special lens.  One side of it is normal, untreated glass.  The other half is treated with what we call an 'Oleophobic' coating.  You'll see what that means in a second."
7. Dip the lens in the oil.  Watch as the oil drains away from one side faster than the other.
8. "One side doesn't like the oil?" or "One side got rid of the oil faster, right?"
9. "So, oleophobic means 'afraid of oil,' and which side do you think is the oleophobic side?"

10. (Optional Explanation) “Have you heard of Oleo? Your parents might have. Grandparents definitely. It was a brand name for margarine. Margarine is made of oil. ”
11. “It’s oleophobic because scientists have created coatings that don’t like oil. They can do it with something called nanotechnology: have you heard of it?”
12. Go into an explanation of what nano means. Use a definition, metaphor, explanation that you’re comfortable with: “It’s a billionth of a meter, etc.” In this case, we’re not only pointing out that nano is small, but we’re emphasizing that nanotech exhibits “new and different behavior” of an engineered material.
13. Scientist altered the coating’s surface, by manipulating the molecules in the coating at the really really small scale to create a surface that the oil is not attracted to. For example, the len’s coating is 3-4 nm thick! In fact, the oil is attracted to itself more than it’s attracted to the surface of the lens. What’s cool is that that scientists created this material to repel water and alcohol, too. (You can always experiment with other, low surface tension liquids that are non-reactive.)
14. Let’s return to our graffiti board. So, the graffiti didn’t stay here. Now, if you take what I’ve just shown you: why does the marker ink not stay on the board? Yes! Nano! There are nano particles of silicon that scientists are able to attach oil and water hating molecules to! (The formulas are proprietary for both the Aculon lens and anti-graffiti coatings, but there are some basic facts about them, noted in the script, that you can mention).
15. *You might want to drop a little bit of oil on the treated metal shingle, and you can also drop a little bit of alcohol. Both are low surface tension liquids.* You will see a difference in the oil’s contact angle (It’ll be higher, not necessarily bead like, but it’ll stick to itself more than the surface).
16. Have the kids feel the difference between the untreated and treated shingles. Ask for their observations.
17. Both the lens and the board have something in common: we know that they repel low surface tension liquids! If our markers also used oil, they would also be repelled! A good anti-graffiti coating needs to repel oil and water.
18. Where can this stuff be used? We know they can used to prevent graffiti! What about something that you touch? You have oil on your hands! How about electronics with glass touch screens?! How about clothes or uniforms?
19. How about a pipe? Why would you want an oleophobic pipe? In engines: there’s a lot of oil in engines! Or in oil pipelines!
20. “I want you to keep thinking about this because it’s fun to imagine the future with nano!!”

## Tips and troubleshooting

How to make anti-graffiti shingles:

1. Before starting: you'll need shingles, rubbing alcohol, tarp/newspaper, protective gloves, painter's mask, clamp/tongs, rag, lint-free cloth, and the Seicoat GPA 300 aerosol spray coating. (http://www.seichemical.com/products.php?cat=7) If needed: a Dremel tool or metal file.
2. If your shingles have very sharp corners, you'll need to round out the corners so that your visitors don't cut themselves. Use a Dremel or a metal file to round the corners. Many museum tool shops should be able to help you in this regard. **Do this for both treated and untreated shingles!**
3. Place a newspaper or tarp on a clean table or ground. Make sure you're in a relatively clean, open area with stable air. You don't want breezes or dust/debris blowing onto the surface as the coating dries. Under a hood would be a good place, too, as long as it's in a fairly clean room.
4. Now would be a good time to put on protective gloves, eye protection, and mask, just in case.
5. Once you have the shingle, wipe it down with a cloth, clean it thoroughly with alcohol, then wipe it again with a lint free cloth. Make sure the alcohol is completely dry before applying the Seicoat coating.
6. Before applying the coating, shake the can vigorously, and you may want to spray a bit of it off to the side to clear up any dry bits in the line. You'll get a much more even coat this way.
7. If you have many shingles, line them up end to end. Keep the can about 1 foot away, and give the shingle(s) a nice even coating: don't apply too liberally! Wait 4 hours, and give the shingles one more quick coating (don't wait too long: +12 hours) because the top layer won't be able to set once the first layer permanently sets). Give the shingles 24 hours to dry (48+ hours is best).

Cleaning the <u>untreated</u> shingle: Soak the tip of a rag or paper towel with the alcohol, then rub the Sharpe ink away with the alcohol tipped rag/towel. In this case, the rubbing alcohol is acting as a solvent. You could use individual alcohol wipes, but this is wasteful and you'll occasionally use more than one wipe on a shingle.

Cleaning the treated side: During the course of the demo, you'll need to clean the ink from the treated side. If you have an evenly coated shingle, this should be easy: all you need to do is dab a wet cloth on the Sharpie ink. Be careful to not rub it! The coating may come off with a vigorous wiping action. If the ink looks like it's not completely coming off, after the demo is done, dab some alcohol on the affected areas and gently clean it up.

Eventually, the coating may wear off. Attempt to get as much of the coating off as possible through using a variety of mild solvents (alcohol or acetone) or fine grit sand paper (or a combination of). Then repeat the steps to make a new shingle.

You can use multiple sizes of shingles (small square ones seem to work best) or experiment with other substrates (the material that you apply the coating to). Painted wood substrate works well, but it can be hard to clean the untreated paint with alcohol. Professional or pre-painted wood would be best. Seicoat GPA300 works with cement, but since it's porous, you may need to be fairly liberal with your coatings. Applying the coating to a paper filter makes it hydrophobic, and oil slowly filters through. You can coat plastic: Polyvinyl has been tried, but the coating doesn't stick to it well.

## Universal Design

This program has been designed to be inclusive of visitors, including visitors of different ages, backgrounds, and different physical and cognitive abilities.

**The following features of the program's design make it accessible:**

[ x ] 1. Repeat and reinforce main ideas and concepts

[ x ] 2. Provide multiple entry points and multiple ways of engagement

[ x ] 3. Provide physical and sensory access to all aspects of the program

Refer to the individual program guides for each activity for specific features or modifications

- With the shingles, create an environment where all genders are welcome: encourage expressing their creativity. Graffiti is an almost universal in terms of creative expression. We want to make sure to direct that energy into something positive.
- Unfortunately, this is a very visual demo. If someone who is vision impaired wants to be engaged, be prepared to let them feel the surfaces, and be very vocal/descriptive of what's happening. Have lint -free towels (Kimwipes) at the ready if they want to feel the lens before and after its been dipped in oil

This project was supported by the National Science Foundation under Award No. 0940143. Any opinions, findings, and conclusions or recommendations expressed in this program are those of the author and do not necessarily reflect the views of the Foundation.

Published under a Creative Commons Attribution-Noncommercial-ShareAlike license: http://creativecommons.org/licenses/by-nc-sa/3.0/us/