nanOntario

Centre for Nanomaterials in Manufacturing Innovation

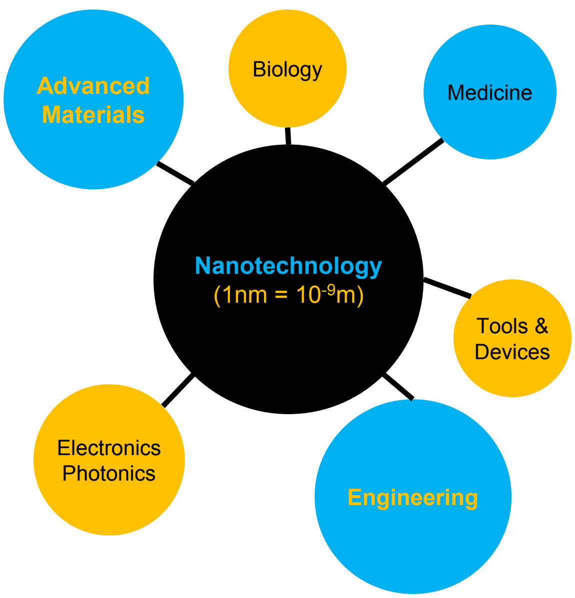
Learning Nanotechnology from Ontario's Great Outdoors

Materials Science & Engineering UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCE & ENGINEERING

What is Nanotechnology?

- nanos: Greek word for "dwarf"
- scale: one-billionth (e.g. 1nm = 1×10^{-9}m)
- a multi-disciplinary field for designing, fabricating, and applying nanometre-scale materials, structures, and devices at sizes less than 100nm



Scanning Electron Microscopy

Nanotechnology's Most Valuable Tool

Scanning Electron Microscopes (SEM's) are used to obtain high-resolution images of sample surfaces using a focused beam of electrons that interact with atoms on a sample surface. SEM's can offer 300x the magnifying power of a traditional optical microscope. The result: **the ability to observe and manipulate materials at the nano-scale level, hence – the evolution of nanotechnology.**

Photo: Sal Boccia, Engineering Technologist, and MSE Graduate Students with Hitachi Environmental SEM, SU6600

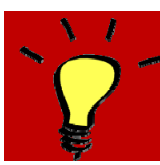
Message from the Publisher | Professor Uwe Erb

What do moth eyes that enhance vision in low-light, aspen tree leaves that stay dry and clean, and brilliantly coloured blue jay feathers all have in common? They are all effects of nanotechnology, perfected by nature over millions of years. And, they can all can be found right here in Ontario.

Welcome to nanOntario, Learning Nanotechnology from Ontario's Great Outdoors. nanOntario is a new Youth Outreach Program designed to introduce high school students to the fascinating world of nanotechnology. Launched in 2009, nanOntario is currently being developed within the Centre for Nanomaterials in Manufacturing Innovation (CNMI), a new initiative jointly funded by the Ontario Research Fund for Research Excellence (ORF-RE), the University of Toronto, and several private sector partners. The Centre will be located in the Department of Materials Science & Engineering at the University of Toronto and will focus on the development of innovative high-tech nanoproducts that will enhance the competitiveness of Ontario's manufacturing sector.

Nanotechnology is at the forefront of the next industrial revolution. Controlling and manipulating matter on a length scale of one nanometer (1×10^{-9} m, i.e. the size range of atoms and molecules), has been the vision of materials scientists and engineers for many years. Over the last two decades, enormous progress has been made in developing new tools, such as the scanning electron microscope, to look at and manipulate matter at the atomic scale. Today, we are ready to apply this knowledge to solve many engineering problems and to come up with new products the world has never seen before. With the projected market size of several trillion dollars by 2015, nanotechnology industries will need many highly skilled people in the years to come, paving the way for excellent career opportunities for students who are just about to start their post-secondary education.

One area of nanotechnology known as bio-mimicry, in which we let nature guide us through breathtaking examples of nanotechnology, provides the blueprint for manufacturing products with incredible properties. Each year, nanOntario will develop one particular theme area, beginning with this year's "Dry and Clean Surfaces" based on the natural phenomenon, The Lotus Effect. Through a unique micro/nano structuring of the leaf surface, water is never retained on the leaf surface, but instead, rolls off easily while removing dirt particles at the same time. This same effect is found on several aspen trees which grow in Ontario's great outdoors. Using the Lotus Effect principles, several industries have adopted this micro/nanostructuring concept to develop products such as stain-resistant fabrics for shirts and pants, fast-drying umbrellas, and self-cleaning house paint. It is remarkable what we can learn from nature – let us begin our fantastic journey.



1 nm is about 1/100,000 width of a human hair

1. The Theory

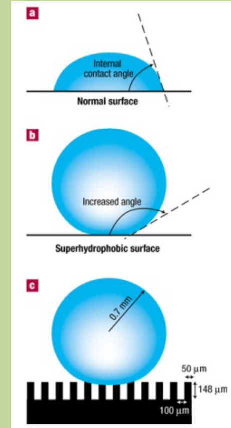
The Lotus Effect

The Lotus Effect refers to the high-water repellency and self-cleaning surface characteristics exhibited by the leaves of the lotus flower (*Nelumbo Nucifera*). This natural phenomenon is attributed to a unique nano-structure found on the leaf's surface. Today, a number of commercial products that provide the same "dry and clean" properties are designed and manufactured based on The Lotus Effect.

Contact angle determines the ability for water to remain on or be repelled by a surface. "Water-retaining", or hydrophilic surfaces, have a contact angle of less than 90^0 between the surface-to-water interface. "Water-repelling", or hydrophobic surfaces, have a contact angle greater than 90^0, resulting in the formation of spherical water droplets. Super-hydrophobic surfaces, such as the lotus flower leaf, have a contact angle greater than 150^0.

This super-hydrophobic contact angle is the result of a bumpy wax-based nano-structure found on the leaf surface. The rough "nano-bumps", combined with the water-repelling nature of wax, gives lotus flower leaves its super-hydrophobic surface properties.

The "self-cleaning" property is a direct result of the super-hydrophobic surface. As water is unable to retain on the leaf's surface, spherical water droplets are formed. When the droplets roll off the leaf, it cleans the surface by removing dirt and other particles with it.



www.nature.com

a) Normal surface, contact angle < 90^0
b) Superhydrophobic, contact angle > 90^0
c) Wax-based nano-structure surface

2. The Applications

STO Lotusan House Paint

ISPO, a German paint company, applied the Lotus Effect principle and manufactured a "clean" exterior house paint named the Lotusan paint. The paint is guaranteed to stay stain and residue-free for 5 years without cleaning detergents or sandblasting. The result: exterior walls that stay clean and retain their colour integrity with little to no maintenance.

A number of buildings in Ontario have employed the use of the Lotusan paint, including the Renaissance Hotel and the Planet Hollywood in Niagara Falls, and the Custom Home in Ancaster.

Left: Exterior wall without vs. with STO Lotusan paint

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Nano-Tex Spills Resistant Fabrics

Nano-Tex, a nano-engineered textile products manufacturing company, applied the Lotus Effect principle and developed a spills resistant fabric.

The critical component in creating long-lasting spills-resistance and self-cleaning properties in fabrics is the surface structuring of individual cotton threads. Conventional fabrics use polymer additives that form a cross-linked network on the cotton surface (figure 1a). Nano-Tex fabrics assemble their polymer additives in a linear fashion, better mimicking the lotus leaf surface, thereby achieving optimum spill/stain resistance (figure 1b).

Nano-Tex has partnerships with North American companies such as Mark's Work Wearhouse, GAP, and Puma, for commercialization of spills-resistant products.

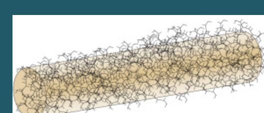

Fig. 1a) x-linked Assembly

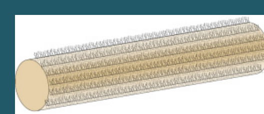

Fig. 1b) linear ordered Assembly

www.nanotex.com

3. The Tool

Scanning Electron Microscope

Scanning Electron Microscopes (SEM) are essential tools when it comes to the development of nanomaterials for advanced applications. In partnership with Hitachi High-Technologies Canada Inc. (HHTC), nanOntario has prepared a mobile educational kit that includes a tabletop SEM (TM-1000) complete with ready-to-use leaf samples from Ontario's outdoors that exhibit the Lotus Effect, Lotusan paint, and Nano-Tex fabric samples. For more information on how to bring this kit to your classroom, please contact, Luke Ng, Liaison Officer, at 416-946-3211, or e-mail lukeyh.ng@utoronto.ca.

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