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Dr. Robert H. Lacombe
Chairman
Materials Science and Technology
CONFERENCES, LLC
3 Hammer Drive
Hopewell Junction, NY 12533-6124
Tel. 845-897-1654, 845-592-1963
FAX 212-656-1016
E-mail: rhlacombe@compuserve.com

TO SEE A SURFACE IN A DROP OF WATER

EDITORIAL COMMENTS

The poet William Blake begins his famous poem Auguries of Innocence with the lines:

> *To see a world in a grain of sand,*
> *And a heaven in a wild flower,*
> *Hold infinity in the palm of your hand,*
> *And eternity in an hour.*

In this issue of the Newsletter we improvise on Blake's haunting words by replacing the grain of sand with a drop of water and instead of the world we look only at surfaces. One can argue that even if surfaces contain a near infinitesimal fraction of the world's matter they are the only entities we really ever see and nearly ever interact with. Also, by far the most accessible and readily available method for investigating surfaces is the CONTACT ANGLE experiment, and thus the drop of water, which is thus the main topic of this issue, provides a magic window into this hidden world which we look at every day by very rarely truly see.

The field of contact angle and wettability behavior has undergone a remarkable resurgence in recent years. Notably, a recent article in C&EN news points out that the seminal papers of Cassie and Baxter (published in 1944 on superhydrophobic surfaces) and the work of Wenzel (published in 1936, theory behind superhydrophobic surfaces) are now among the top 15 cited papers in science. In addition, a whole raft of new phenomena are being investigated including electro wetting, nano and micro fluidics, superhydrophobicity, patterned surfaces and self cleaning surfaces to name just a few. It is indeed no exaggeration to claim that a true Renaissance in the science of liquid/solid interactions and wetting behavior is now underway with enormous implications not only for our fundamental understanding of molecular interactions at surfaces but also for the development of many applications of industrial and commercial interest.

Two items of major interest will be our primary focus. The first is the issue of ice adhesion and the second is the upcoming:

> ELEVENTH INTERNATIONAL SYMPOSIUM ON CONTACT ANGLE WETTABILITY AND ADHESION to be held June 13-15, 2018 at the Stevens Institute of Technology, Hoboken, New Jersey, USA.

We cordially invite all readers of the newsletter to join us at this event where many of the latest research efforts on this most common but nearly universal surface analysis method will be discussed and commented upon in great detail.

ICE ADHESION

Ice storms are often winter's worst hazard. More slippery than snow, freezing rain or glaze is tough and tenacious, clinging to every object it touches. A little can be dangerous, a lot can be catastrophic.

Ice storms are a major hazard in all parts of Canada except the North, but are especially common from Ontario to Newfoundland. The severity of ice storms depends largely on the accumulation of ice, the duration of the event, and the location and extent of the area affected. Based on these criteria, Ice Storm'98 was the worst ever to hit Canada in recent memory. From January 5-10, 1998 the total water equivalent of precipitation, comprising mostly freezing rain and ice pellets and a bit of snow, exceeded 85 mm in Ottawa, 73 mm in Kingston, 108 in Cornwall and 100 mm in Montreal. Previous major ice

storms in the region, notably December 1986 in Ottawa and February 1961 in Montreal, deposited between 30 and 40 mm of ice - about half the thickness of the 1998 storm event!

The extent of the area affected by the ice was enormous. At the peak of the storm, the area of freezing precipitation extended from Muskoka and Kitchener in Ontario through eastern Ontario, western Quebec and the Eastern Townships to the Fundy coasts of New Brunswick and Nova Scotia. In the United States, icing coated Northern New York and parts of New England. The effect of this storm on the power industry is dramatically illustrated in figure (1).

The following is a list of the direct consequences on the Canadian population:

Figure 1 Dramatic evidence of the power of ice on the power industry. One hundred foot tall towers carrying power lines are seen here bent like blades of grass in the aftermath of the 1998 ice storm that hit southeastern Canada and the Northeastern US.

- At least 25 deaths, many from hypothermia.
- About 900,000 households without power in Quebec; 100,000 in Ontario.
- About 100,000 people took refuge in shelters
- Residents were urged to boil water for 24 to 48 hours.
- Airlines and railways discouraged travel into the area
- 14,000 troops (including 2,300 reservists) deployed to help with clean up, evacuation and security.
- Millions of residents forced into mobile living, visiting family to shower and share a meal or moving in temporarily with a friend or into a shelter.

Each of the above listed consequences of the storm was either directly or indirectly due to the fact that the storm had knocked out nearly all of the electrical power serving southeastern Canada. Prolonged freezing rain brought down millions of trees, 120,000 km of power lines and telephone cables, 130 major transmission towers each worth $100,000 and about 30,000 wooden utility poles costing $3000 each. The damage in eastern Ontario and southern Quebec was so severe that major rebuilding, not repairing, of the electrical grid had to be undertaken. What it took human beings a half century to construct took nature a matter of hours to knock down.

As a result of the havoc wreaked by the storm, the Canadian government has now apparently developed an interest in ways to prevent ice accumulation on power lines, and, you guessed it, using contact angle measurements to unveil the underlying surface interactions between ice and power lines is one of the approaches

being taken.

Some of the most recent progress on the problem of ice adhesion has been presented in a paper by Golovin et al. ("Designing durable icephobic surfaces", Sci. Adv. 2016; 2 : e1501496 11 March 2016). The authors show that, irrespective of material chemistry, by tailoring the cross-link density of different elastomeric coatings and by enabling interfacial slippage, it is possible to systematically design coatings with extremely low ice adhesion (σ_{ice} < 0.2 kPa) where σ_{ice} is a measure of the shear stress required to remove the ice from a surface given by:

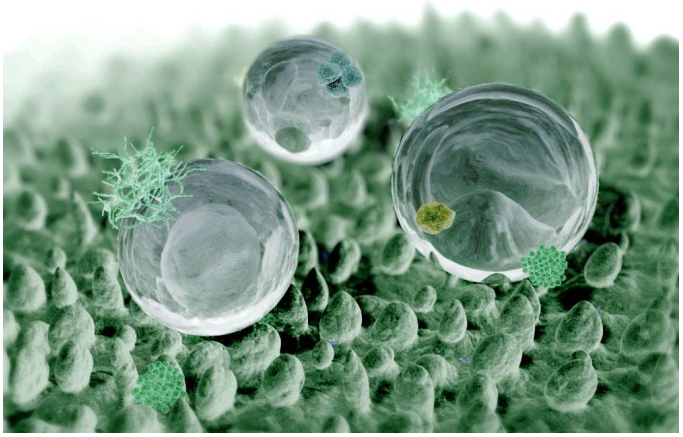
$$\sigma_{ice} = A(W_a G/t)^{½}$$

Where:

A = Experimental constant
W_a = Work of adhesion
t = Coating thickness

Whereas σ_{ice} on surfaces such as aluminum and steel are in the range of 1,400 - 1,600 kPa this work seeks to develop coatings that limit σ_{ice} to less than 100 kPa. Indeed the authors claim that through the use of appropriately fabricated elastomeric coatings and by carefully controlling the surface crosslink density, they can implement the rational design of icephobic coatings with virtually any desired ice adhesion strength. Also they claim that that the coatings are able to maintain σ_{ice} < 10 kPa after severe mechanical abrasion, acid/base exposure, 100 icing/deicing cycles, thermal cycling, accelerated corrosion, and exposure to severe wintery conditions over several months.

Ice adhesion is but one of the topics to be covered in the upcoming CONTACT ANGLE symposium which is the topic we now turn to.



ELEVENTH INTERNATIONAL SYMPOSIUM ON CONTACT ANGLE, WETTABILITY AND ADHESION

Stevens Institute of Technology, Hoboken, New Jersey, June 13-15, 2018

SYMPOSIUM HISTORY AND MOTIVIATION

In his opening remarks at the first symposium in this series Professor Robert Good pointed out that Galileo in the 17th century was quite likely the first investigator to observe contact angle behavior with his experiment of floating a thin gold leaf on top of a water surface. Since that time contact angle measurements have found wide application as a method for determining the energetics of surfaces. This, in turn, has a profound effect on the wettability and adhesion of liquids and coatings to surfaces.

This symposium will be concerned with both the fundamental and applied aspects of contact angle measurements. Issues such as the applicability and validity of various measurement techniques and the proper theoretical framework for the analysis of contact angle data will be of prime concern.

In addition, a host of applications of the contact angle technique will be explored including but not limited to: wettability of powders, fibers, wood products, paper, polymers and monolayers. Further focus will be on the use of contact angle data in evaluating surface modification procedures, determining relevance of wettability to adhesion, the role of wettability in bioadhesion, ophthalmology, prosthesis and in the control of dust in mining and milling applications.

AUDIENCE AND PARTICIPATION

The primary focus of this symposium will be to provide a forum for the discussion of cutting edge advancements in the field and to review and consolidate the accomplishments which have been achieved thus far.

SUBMITTING A PAPER

This symposium is being organized under the direction of Dr. K. L. Mittal, Editor, Reviews of Adhesion and Adhesives and by MST Conferences. Please notify the conference chairman of your intentions to present a paper as early as possible. An abstract of about 200 words should be sent by March 15, 2018 to the conference chairman by any of the following methods:

E-mail: rhl@mstconf.com
FAX: 212-656-1016
Regular mail:

Dr. Robert H. Lacombe
Conference Chairman
3 Hammer Drive
Hopewell Junction, NY 12533

Contact by phone: 845-897-1654; 845-592-1963

Full conference details and registration via the Internet will be maintained on the MST web site:

www.mstconf.com/Contact11.htm

SYMPOSIUM TOPICS:

Factors Influencing Contact Angle Measurements:

- Static and dynamic contact angles, effect of surface flaws and surface roughness on wetting.
- Effect of pore size distribution
- Effects of velocity and viscosity of liquid on solidliquid interfacial behavior.
- Interaction forces including: van der Waals, Acid-Base, Hydrogen bonding, ...etc

Wettability Behavior and Surface Characterization of Various Materials:

- Contact angle interpretation and hysteresis.
- Wettability of various material surfaces including but not limited to: wood, elastomers, silicon wafers, pharmaceutical powders, metals, polymers, paper, particles, fibers... etc.
- Surface treatments to modify wettability behavior.
- Superhydrophobicity
- Electrowetting

Wettability, Adhesion and Applied Aspects of Contact Angle Measurements:

- Effect of surface energetics on adhesion.
- Biological applications including protein and bacterial adhesion.
- Fine particle adhesion and control of dust.
- Other technological applications including: printing, agriculture, pharmaceuticals, textiles and paper.

0RGANIZERS AND CONTACT INFORMATION

Dr. Chang-Hwan Choi
Associate Professor
Dept. of Mechanical Engineering
Stevens Institute of Technology
Castle Point on Hudson
Hoboken, NJ 07030
Tel. 201-216-5579
E-mail: cchoi@stevens.edu

Dr. Kash Mittal, Director
HERITAGE EXECUTIVE SUITES
Suite 1, 2537 Route 52
Hopewell Junction, NY 12533
USA
Tel. 845-897-1654
FAX: 845-897-2361
E-mail: klm@mstconf.com

Dr. Robert Lacombe
HERITAGE EXECUTIVE SUITES
Suite 1, 2537 Route 52
Hopewell Junction, NY 12533
USA
Tel. 845-592-1963
FAX: 212-656-1016
E-mail:rhl@mstconf.com