STUDENT LABORATORY WORKSHEET EXPERIMENT D:

SUPERHYDROPHOBIC MATERIALS

Student name:……

Date:……..

AIM: - Understanding of the presence of nanostructures on the composition of a natural material and how these affect its properties
- Novel advanced materials that have been engineered at the nanoscale to be superhydrophobic and their applications
- Analysis of a functional nanomaterial under research at iNANO (through a video)
- Analysis and hands-on test of a superhydrophobic textile

BEFORE YOU FILL IN THIS WORKSHEET:

- read the STUDENT BACKGROUND sheet for EXPERIMENT D
- ask your teachers questions if you have any

MATERIALS:

- Different surfaces to test:
  * 1 microscope glass slide
  * 1 flat piece of plastic 10x10 cm (e.g. cut a piece out of a plastic sheet such as a plastic folder)
  * 1 flat piece of aluminium foil 10x10 cm
  * 2 pieces of filter paper
  * Pieces of textiles to compare (about 10x10 cm):
    - 4 of Nano-Tex®and two other types
    - 3 samples of 100% cotton
    - 3 samples of fabric made with synthetic fibre such as polyester or cotton/poly blend (in this protocol we used a fabric with 70% polyester, and 30% cotton)

- Different stain agents to test
  * 1 glass of water, 1 glass of juice and/or 1 glass of coke
  * Balsamic vinegar or wine (1 glass)

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* Cooking oil (1 glass)
* Ketchup (1 spoonful)
* Mustard (1 spoonful)
* Mayonnaise (1 spoonful)
* Organic soil (a couple of handfuls)

- Different plant leaves (collect from school garden or bring from home)
  * One common plant leaf such as ivy
  * One piece of lotus leaf or nasturtium
- Laboratory bottle filled with water
- 5 eyedroppers (or Pasteur pipettes) to apply the liquid stain agents - Plastic knives or spoons for applying the other stain agents
- A bucket of laundry detergent and water (you might need to share this with the entire class)
- A 10x10 cm piece of sandpaper
- 1 permanent marker
- Several plastic cups to hold water and stain agents
- Several plastic plates to put materials on when conducting the material testing
- Paper glue and scissors

SAFETY NOTE: This experiment doesn't use chemicals but only common liquids and solids. Nevertheless staining is possible so wash hands and surfaces thoroughly after handling. Use appropriate clothing protection, gloves and eye protection. Collect all liquids and washing water in glass/plastic containers and dispose of in sink. All experiments will be carried out at your own risk. Aarhus University (iNANO) and the entire NANOYOU consortium assume no liability for damage or consequential losses sustained as a result of the carrying out of the experiments described.

PROCEDURE

You will now test a series of materials, starting from common ones and moving towards more advanced ones. When you test the materials with water or other liquids/solids, do so by placing the material on a plastic plate in order to collect the water neatly. **Dispose of the collected water between tests!**

1. Understanding surface properties: Hydrophilic and hydrophobic

- Take the four surfaces to test: a glass slide, a piece of plastic, aluminium foil, wood, filter paper. Place a couple of droplets of water on each material, and record your observations in the table in the next page:

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Material	Hydrophilic or Hydrophobic?	Comments
Aluminium		
Plastic		
Filter paper		
Glass		

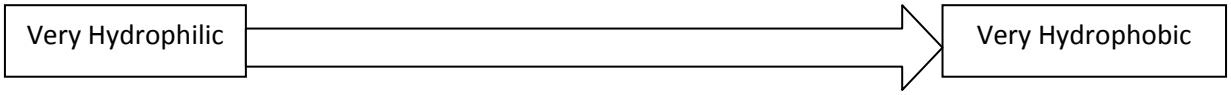
Based on your visual observation, classify the materials as hydrophilic or hydrophobic (fill table).

Q1. Did filter paper behave like the other materials? If not, why?

……

Q2. Put **aluminium, plastic and glass** in a scale, starting from the most hydrophilic to the most hydrophobic, based on your visual observation.

……



Q3. Would you define any of the material tested so far as “very hydrophobic”? Why?

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Q4. Now cut out the photos in the last page of this document, and paste them below to recreate the same scale you have just made in Q2. Write under each photo the material you think it is.

2. Analysis of natural nanomaterials: the Lotus leaf (or Nasturtium)

STEP 1

- Put in one plastic plate a leaf of common plant you have collected (e.g., edera). If you have more than one, test each independently.

- Pour some water over each leaf and observe how water rolls off the surface. A bucket or other container should be used to collect the water. A paper towel should be on hand.

- Q5: Do the water droplets wet the surface of the leaf (i.e. is water left on the leaves once you stop pouring water)? Give an answer for each type of leaf you have tested.

……

……

- Q6: Do the water droplets roll or slide over the leaf?

…….

STEP 2

- **Now in a second plastic plate place a leaf (or a piece of it) of lotus or nasturtium** (depending on what your teacher gave you).

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- Q7: Do the water droplets wet the surface of the leaf (i.e. is water left on the leaves once you stop pouring water)? Give an answer for each type of leaf you have tested.

……

- Q8: Do the water droplets roll or slide over the leaf?

……..

- Q9: What happens if you place the leaf horizontally on the bench and splash it with water?

……..

- Q10: Can you get a droplet to remain motionless on the surface? Is it easy or difficult? What does this tell you about the surface properties of the leaf?……..

- **Place the lotus leaf or nasturtium leaf under running water.**

Q11: Even after running the leaf under water, does it become wet?

……..

Q12. Based on your observation, is the lotus leaf (or nasturtium leaf) more or less hydrophobic than plastic?

……..

Q13. Where would you place the photo of the contact angle of a lotus leaf (provided at the end of this document) in the scale you made in Q4? Cut out all the photos again and make a new scale below, writing under each the type of material.

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STEP 3

- Watch the **NANOYOU Video 4 Lotus Effect®-Part 2**, which shows a surface engineered at iNANO (Aarhus University), which has surface properties comparable to those of the Lotus leaf (superhydrophobic).

Q14. How does the porous silicon material shown in the video compare with the lotus leaf in terms of surface properties?

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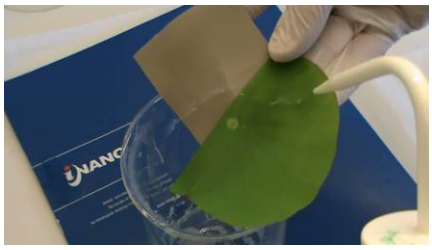
3. Analysis of a functional nanomaterial. In this part of the experiment you will analyse a textile that has been engineered to replicate the Lotus Effect® and have self-cleaning properties



- Take 1 piece of Nano-Tex® and 1 piece of a normal cotton fabric. Place each in a plastic plate.

- Pour some water over them. If possible, use a lotus or nasturtium leaf for comparison.

Q15. Does the Nano-Tex® fabric behave like the Lotus Effect® in terms of how water wets it?

……..

- Now you will test the Nano-Tex® fabric and compare it with normal cotton and a semi-synthetic fibre. For this you need **in total** 3 pieces of cotton fabric, 3 pieces of a semi-synthetic fabric, and 4 pieces of Nano-Tex® (each about 10x10 cm). **Follow the steps below**.

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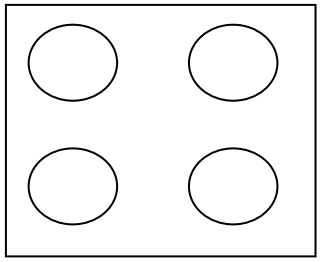
STEP 1.

Now you should test the Nano-Tex® fabric and compare it with normal cotton and a semi-synthetic fibre. In this step liquid stains should be used (coke, vinegar, oil, etc.)

- Get a glass of each of the liquids you will test (juice, coke, vinegar or wine, and oil).

- Place your 3 pieces of different fabrics in a row: left cotton, middle semi-synthetic, right Nano-Tex®. Write on a piece a paper the type of fabric and place it under each fabric (as in the image below). Decide in which order you will test the liquids and write it here:



- Using a pipette, **place a droplet of each liquid to be tested on each fabric**. *You should let the solutions stay on the 3 type of fabrics for a fixed amount of time.* Indicate this on the table below. *Perform this test sequentially, one liquid and one fabric at the time.*

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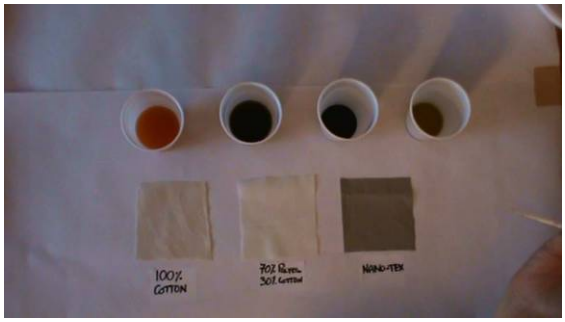

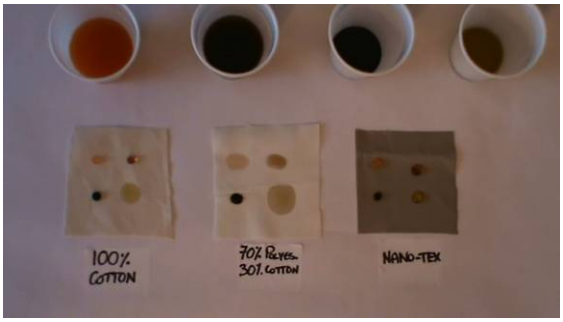

- After the set time, gently remove the liquid from after fabric using a piece of kitchen paper.

Record your observations in the table provided. Write down whether the liquid was absorbed, whether it remained on the fabric surface, whether it stained the fabric, and whether you could remove it with the paper cloth. Add any more comments you have.

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	Time of liquid staining: ……seconds (*fill in*)			
Material	**Juice**	**Coke**	**Vinegar or Wine**	**Oil**
Cotton fabric				
Semi-synthetic fabric				
Nano-Tex®				

Q16. Was there a clear difference between the Nano-Tex® fabric and the other fabrics? Describe.

……..

……..

Q17. How easy was it to remove the liquid stains from the Nano-Tex® fabric? Did all the liquid stains come off?

……..

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STEP 2

Now you should test the Nano-Tex® fabric and compare it with normal cotton and a semi-synthetic fibre. In this step solid stains should be used (mayonnaise, mustard, etc.)

- Now test the three types of fabrics with the "solids" chosen: ketchup, mustard, mayonnaise. Have some paper on hand.

- **Take 3 new pieces of fabric, one for each type**. Place some of each solid on each fabric. Use a spoon or spatula to place the solid on the fabric. On one area available mark it with a permanent marker (see Figure).
- To compare the fabrics you must define a set time of staining for this experiment (e.g. 5 min).

- After a set time (e.g. 5 min), remove the solids from the fabrics, using a **wet cloth.**

NOTE! Be careful not to mix the different solids.

In the table below, record your observations on how each solid stains the fabrics.

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	Time of solid staining: ……seconds (*fill in*)			
Material	**Ketchup**	**Mustard**	**Mayonnaise**	**Permanent marker**
Cotton fabric				
Semi-synthetic fabric				
Nano-Tex®				

Q18. Was there a clear difference between the Nano-Tex® fabric and the other fabrics? Describe.

……..

……..

Q19. How easy was it to remove the solid stains from the Nano-Tex® fabric? Did all the solid stains come off?

……..

……..

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STEP 3

Now you should test the Nano-Tex® fabric for resistance to dirt and compare it with normal cotton and a semi-synthetic fibre. In this step organic soil is used.

-**Take 3 new pieces of fabric, one for each type.**

- Place some organic soil in the middle of each piece, fold the fabric and rub it. Then open each piece of fabric, remove the soil from each, and observe.

Q20. Did all the fabrics get dirty? In the same way? Describe.

……

……

- Now try to clean the fabrics used in STEP 3 with your hands.

Q21: Could you clean the fabrics? Is there a clear difference among them? Describe.

……

Q22. Was there a fabric that could be totally cleaned and appear as new?

……

Q23. Which type of fabric could be cleaned more easily?

……

- **Now try to clean the three fabrics used in ALL STEPS with cold water and soap.**

Q24. Do all the fabrics become clean? If not, which one does?

……

Q25. Which type of fabric could be cleaned more easily?

……

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Q26. Is there a type (or more) of stain that doesn't come off from the Nano-Tex® samples? Which one? Why do you think this is so?

……

STEP 4 Test the Nano-Tex® with sand paper.

- You should take 1 new piece of Nano-Tex® and a piece of sandpaper.

- Test it to see **how durable the fabric is**. First observe how water rolls off this fabric. Cut the piece in two. Then take a piece of sandpaper, and rub it over the surface of one of the two pieces. Test the fabric to its limit! **NB** the use of heat is not recommended

Q27. Did the treatment with sandpaper alter the properties of the Nano-Tex® fabric? How does this affect the fabric?

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CREDIT NOTE:

This experiment is partly adapted from the Application activity: Nano-Tex, http://mrsec.wisc.edu/Edetc/IPSE/educators/nanoTex.html.

ACKNOWLEDGEMENTS:

We thank Nano-Tex, Inc. for their courtesy in providing a piece of their Nano-Tex® textile (resists spills), and for providing images of this material. The author wishes to thank Anton Ressine (iNANO, Aarhus University) for providing the porous silicon sample shown in the videos of this experiment.

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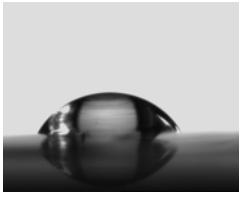
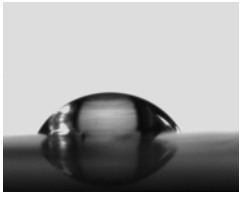
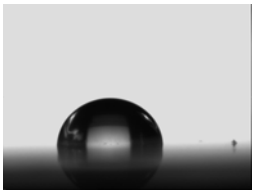
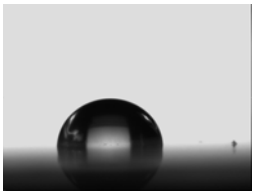
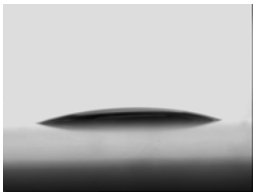
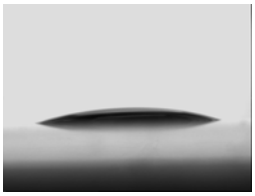
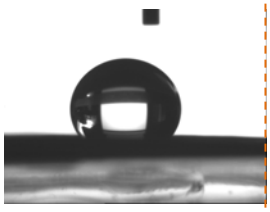
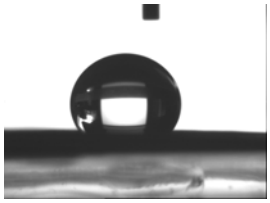
USE THESE IMAGES TO FILL IN Q4 and Q13

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