

## Friday 10th March -Materials Decathlon - Challenge n°8 - 40'

### SELF-FOLDING MATERIALS

*Self-folding is a process that causes a predefined 2D template to fold into a desired 3D structure with high fidelity. Self-folding may be useful for packaging, actuation, and sensing. Our approach to self-folding implies drawing patterns of ink on a pre-stressed polymer sheet which will shrink in-plane up to 50-60% by uniform heating over 120 °C. The pre-stressed polymer sheets (Shrinky-Dinks<sup>1</sup>) are a commercially available toy. The black ink (i.e., the hinge) can be patterned using a pen or a desktop printer on either side of the transparent sheets. Hinges absorb selectively the light to heat the underlying polymer and cause the polymer to shrink, while the polymer without black ink pattern doesn't shrink, therefore the 2D patterned polymer sheets can fold into complex 3D structures (e.g., cubes, tetrahedrons) within seconds.*

1. Watch “3D objects just add light” you-tube video (less than 1' long) <https://www.youtube.com/watch?v=NKRWZG67dtQ> from the Dept. of Chemical and Biomolecular Engineering University of North Carolina (USA).
  2. On the desk you have a plastic sheet of the same type shown in the video. This is **Shrinky-Dinky**(SD) a pre-pressed polymer sheet. Draw a geometric figure (like a flat open cube or polyedra) with a black marker. Be careful to draw strong wide black lines on both sides of the sheet. Thin lines do not work! Your challenge is to draw one of such self-folding structures [Suggestion: *DO NOT exaggerate with dimensions: the smaller the better. 2.5 cm for the cube side dimension will be ok!*]
  3. Turn on the hotplate and preheat the temperature to **80-90 °C**. Aluminium foil can protect the surface of the hotplate and a glass slide can provide a flat surface to work on.
  4. Put the patterned SD on the hotplate by using tweezers, and adjust the distance between the infrared (IR) heat lamp and the hotplate to be approx. 5 cm.
  5. Turn on the IR heat lamp and observe the self-folding of patterned SD. **Shoot a video!**
  6. Turn off the lamp (or simply remove the sample from light) upon completion of the folding. If you expose the SD too long to heat, it will deform.
- Q1.** Discuss with your team a possible innovative application for this material.
- Q2.** Shrinky-Dinky is rather expensive, so it's worth looking for alternatives. **Test other plastic samples:** does any of them exhibit the same shrinking behaviour as Shrinky Dinky?

#### OUTPUT WANTED:

- > one video of one of the self foldingshapes +one 3D self-folded [chose the best you were able to made]
- > answer of question Q1 and Q2

<sup>1</sup> polystyrene thermoplastic

**Answer sheet**

**GROUP N° \_\_\_\_\_**

**Ch.8 --- SELF-FOLDING MATERIALS**

**Q1**

**Q2**

**VIDEO** [*Sent by Whatsapp to your group – See general instruction to share pictures or files*]

- **Video description:**

**Remember to give your (best) 3D self folded to the teacher in charge at the end of the activity**

## Teachers' Notes

### Technical notes:

- ???

### Organizational notes:

- Each student will keep a copy of the students' sheet but the group will collectively fill in the answer sheet and give it over to the teacher in charge at the end of the lab.

### Correction grid

Question or Request	Note	Max. score
Q1	Evaluate originality and feasibility	3
Q2	Evaluate if answer is motivated on test	3

**Video + 3D self folded model:** make a ranking from the best to the worse one (consider both video and model – if possible avoid shared position); mark 14 points to the best one, 12 points to the second one, etc.

**Key to Answer:** quantity and quality of self-folding samples obtained by each group

### MoM Resources (<http://www.mattersofmatter.eu/mom-materials/>)

- Video [IR-SELFFOLDING](#)
- Ch2\_TEACH\_EN\_Seeing NIR
- Ch8\_TEACH\_EN\_Temperature&IR
- FCh2\_TEACH\_EN\_Cool roofs
- FCh1\_TEACH\_EN\_window film for solar control

### References

- [https://en.wikipedia.org/wiki/Shrinky\\_Dinks](https://en.wikipedia.org/wiki/Shrinky_Dinks)
- Self-Folding of Shrinky-Dinks: A Science Activity for Middle / High School Students
- (Dr. Michael Dickey & Ying Liu: NC State Chemical Engineering)
- <https://news.ncsu.edu/2011/11/wmsdickeyfolding/>
- Free download at <https://repository.lib.ncsu.edu/bitstream/handle/1840.16/9849/etd.pdf?sequence=2>
- <http://pubs.rsc.org/en/Content/ArticleLanding/2008/LC/b711622e#!divAbstract> for more serious purposes, Shrinky Dink to create Microfluidics

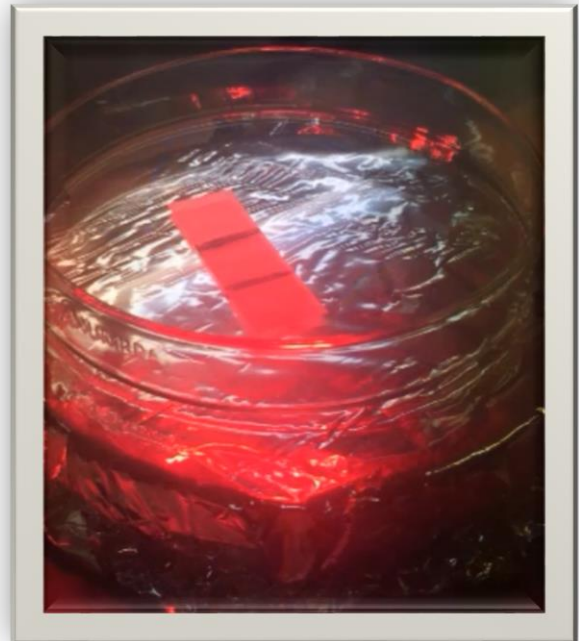
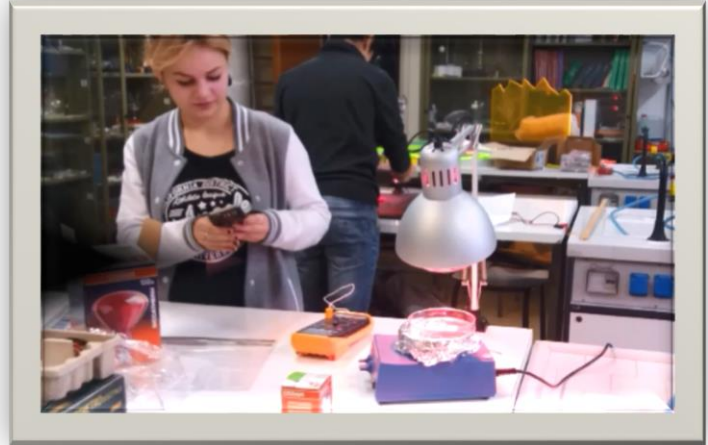
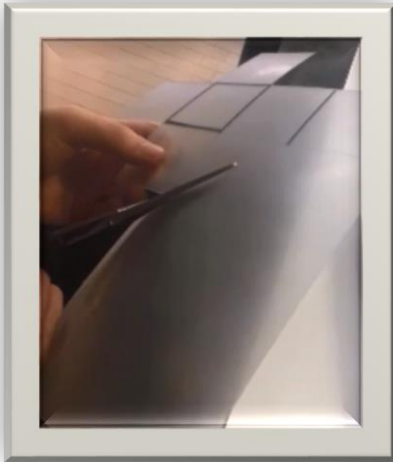
### Where to buy

- **Shrinky dink** –Amazon in toys for children. Sold in sheets  
N.B. However in Italy some packages of Stracchino (soft cheese) make use of the same kind of plastic which can be used at zero cost

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Photogallery



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