

# EINSTEIN MUG

Thermochromic substances exhibit the property of **thermochromism**, an ability of substances to change colour in response to temperature changes.

The two most important groups of materials exhibiting thermochromism are **liquid crystals** and **leuco dyes**.

**Liquid crystals** (LC) undergo crystallic phase changes due to thermal expansion in the crystal, resulting in a change of spacing between the crystal layers. This causes a shift in the Bragg diffraction reflected wavelength. They are used in applications where the temperature change has to be accurately displayed such as in room-, forehead-, refrigerator- and aquarium thermometers. They are also used as propane level indicators in gas tanks. The most famous LC application of all times was the "mood ring" of the 70's.

**Leuco dyes** (also known as "white dyes") allow for a wider range of colours to be used, but their response temperatures are not that accurate, usually in a 3 °C interval.

The Einstein Mug has two rectangular blocks of leuco dye painted over the white pigmented ceramic surface of the mug with black image of Einstein. The  $E = mc^2$  formulas are areas where no dye is applied. At room temperature the dye absorbs light from all wavelengths in the visible spectrum, producing a "black" surface. When hot liquid above 35 °C is poured into the mug, the molecular structure of the dye reversibly changes so that it stops absorbing the visible wavelengths and the dye becomes transparent, changing the appearance of the mug.

Leuco dyes' life span is adversely affected by sunlight (UV), extreme temperatures above 200 °C and contact with aggressive solvents.

Therefore the **care instructions for your mug** are:

- Avoid cleaning with aggressive cleaning chemicals. Hand wash only.
- Store in a dark place. Avoid prolonged exposure to bright and UV light.
- For microwave use: remove when colour change occurs (1 - 2 min). Do not overheat.

We wish you many fulfilling scientific mugs of coffee!

