Structural Color

What is the motivation/goal of the research?

To design a material that incorporates both structural color and the lotus effect, thus mimicking the wings of a butterfly.

How would you identify a material for this function?

What material (and experiment) was identified?

An inverse opal – monodisperse air spheres

a. An optical stop band can be tuned to a specific light wavelength.

b. Rough surfaces of well-ordered meshes decreases wettability, i.e. hydrophobicity.

Surface Effects from Nanostructure

Structural Color and the Lotus Effect**

*Zhong-Ze Gu, Hiroshi Uetsuka, Kazuyuki Takahashi, Rie Nakajima, Hiroshi Onishi, Akira Fujishima, and Osamu Sato**

Angew. Chem. Int. Ed. **2003**, *42*, No. 8

Structural Color

Synthesis of an Inverse Opal – polystyrene spheres (nm), silica nanoparticles at 2% and 0.3% concentration.

Dried in air, calcined at 450^{o}C

Inverse opal material? Silica - SiO_2

Surface modified with fluoroalkylsilane by thermal chemical vapor deposition.

Figure from Chemical Approaches to 3D Photonic Crystals. D.J. Norris, Y.A. Vlasov.

Structural Color

What do you see and/or conclude?

Figure 1

Prepared by dipping a slide into a solution that contains 2 different sized particles.

Size Ratio – 580 / 680 nm = 0.85
230 / 680 nm = 0.34
48 / 680 nm = 0.07

Non close packed (> 0.5)
Phase separation (<0.5, >0.15)
Cubic close packed (<0.15)

Why use two sizes of spheres? (polystyrene spheres and silica nanoparticles)

Structural Color

Experimental characterization?

How does the size of the polystyrene spheres change the color?

Figure 2

Smaller starting spheres = lower wavelength of light

Was that expected?

Structural Color

Electron Microscopy

Figure 3

Individual SiO_2 particles have condensed. Air spheres contracted by ~5%.

Six bumps (~100nm) around each opening. The roughness can enhance hydrophobicity? (theory?)

Figure 5

Structural Color

Hydrophobicity – Measure the angle that water droplets meet the surface.

Modified with fluoroalkylsilane (155^{o} contact angle)

Not modified (100^{o} contact angle).

Figure 4

Surface is superhydrophobic?

Conclusions: 1) Method to fabricate inverse opal with properties of visible color and hydrophobicity.

Structural Color

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Discussion Points

How did the scientists go from fundamental idea → research?

What new fundamental knowledge was discovered?

Was this scientific paper fully convincing in its conclusions?

What other knowledge might be interesting to know? (future research hypotheses?)

In Class Exercise

At the end of the article the authors state, “Such films (inverse opals) are anticipated to become a new generation of decorative materials”. Aside from color and hydrophobicity, what other properties are necessary for a material to be used in the real world?