Biomimetic methods to create new transparent and emotion-responsive biomaterials and their use in Architecture and Design.

HIRHAGER, N. [1, a], CRAWFORD, A. E. [2, b] AND GEBESHUBER, I. C. [3, 4, c]

[1] Faculty for Architecture and Planning, Vienna University of Technology, Karlsplatz 13, 1040 Vienna, Austria
[2] Faculty for Architecture: Spaces and Objects, Central Saint Martins, Granary Building 1 Granary Square, King's Cross, London N1C 4AA, United Kingdom
[3] Institute of Microengineering and Nanoelectronics, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Malaysia
[4] Institute of Applied Physics, Vienna University of Technology, Wiedner Hauptstrasse 8 - 10 / 134, 1040 Vienna, Austria

[a] nicole.hirhager@gmx.at, [b] alys.crawford@googlemail.com, [c] gebeshuber@iap.tuwien.ac.at

NATURE

biomimetic approach

CASTING METHODS

easy

fast

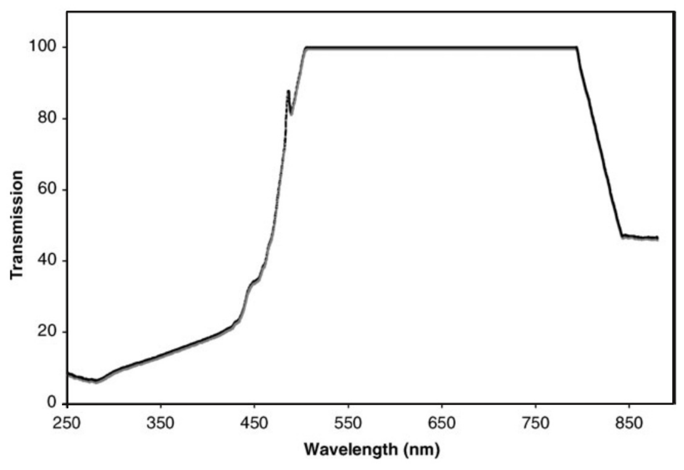
reliable

up-scalable

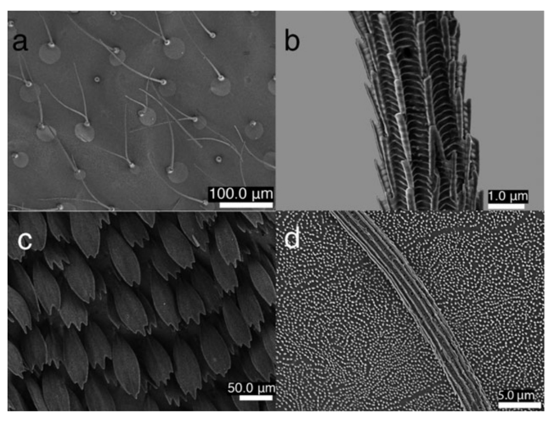
nanostructural analysis

reflectance of light

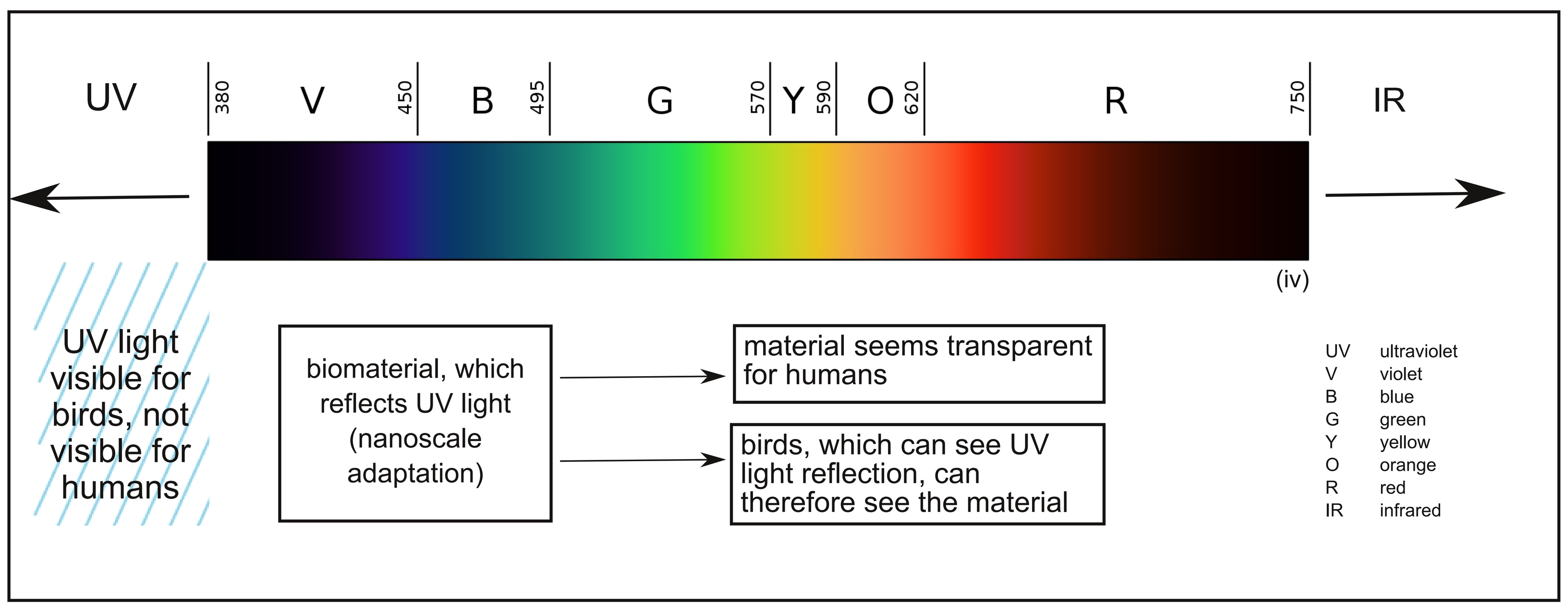
transmission of light

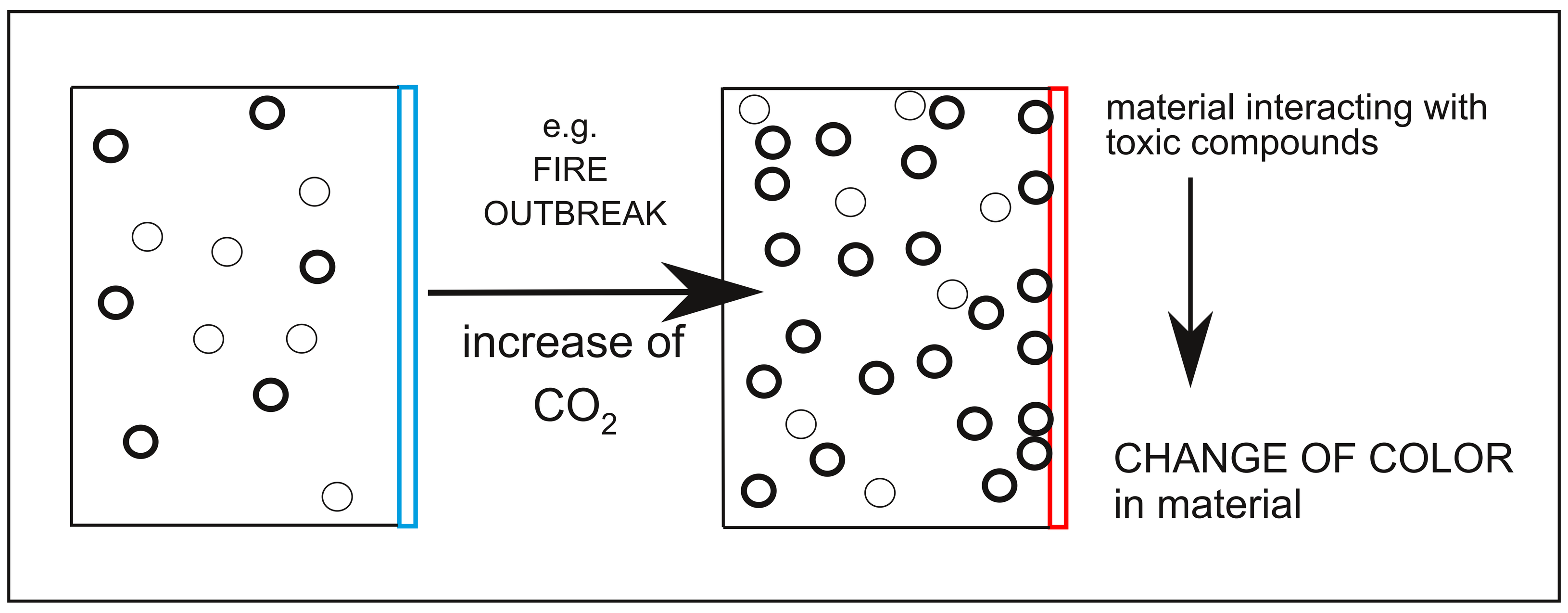


(ii) Transmission spectrum of transparent area of *G. oto* wing over wavelength range of 250-900nm



(iii) Scanning electron microscopy images showing three distinct patterns of *G. oto* wing: **a.** piliform scales on transparent parts, **b.** detail images of piliform scale, **c.** flat scales on brown colored parts, **d.** piliform scale and underlying pattern beneath piliform scales on transparent parts





BIOMATERIALS

in ARCHITECTURE and DESIGN

bird protective glass, UV-light protection, self-cleaing surfaces, antireflective surfaces, display system of emotions, responsive materials as warning system, user defined waterflow on surfaces

nontoxic
reusable
rewritable
environmentally friendly

(i) *Greta oto*

ABSTRACT. Transparent materials play a major role in Architecture, especially concerning the relation between outdoor and indoor spaces. The range of materials used in recent years have focused on glass and synthetics, while Nature has far more to offer. The biomimetic approach is an ideal way to create transparent materials though the transparency in Nature is often not based on material, but on structure. The results of this projects research will be used to develop biomaterials on a structural level and solve current issues in Architecture.
In their natural environment animals use transparency in different ways, either for protection or for the maximization of their given abilities. The transparent features of these animals are analyzed on nanoscale level with casting methods, these being fast, easy, reliable and up-scalable for further use, selection and comparison.
The main object of research in this case is Greta oto, which has mainly transparent wings.
The analysis of the nanostructural functionalities of both the transparent and the non-transparent wing parts shows that also in this case it is the underlying structure, which is responsible for the transparency.
Within our research the transmission of light based on the structural nanoscale level is also studied. Due to the change of these structures light frequence regulation is possible. The understanding of this mechanism allows us to create biomaterials, which can be adapted to specific needs. Examples for this are bird protective glass, being visible for birds due to specific lightwaves, yet invisible for the human eye, or UV-light protective glass, which acts as a filter on nanoscale level.
Changes in the surface structure can also lead to antireflective or selfcleaning materials.
Furthermore, our research results can be applied to fields other than Architecture, focusing on the design aspects of surfaces, textures, and others. The previously mentioned structures can induce user defined waterflows. This can be used as a hidden artistic element, which appears with rainfall.
Apart from these improvements a biomimetic approach can be used for the development of completely new materials. An example for this would be the display of emotions on surfaces and textiles. The underlying mechanism would be a receptor material, which reacts to certain compounds in the air and changes its characteristics depending on their concentration. The display of the biomaterials color change, for example, can indicate rooms in case of toxic contamination, outbreak of fire, domestic violence or high stress, this being a new warning system, visible to the outside.

REFERENCES. Binetti, V.R. et al., 2009. The natural transparency and piezoelectric response of the Greta oto butterfly wing. *Integrative Biology*, [e-journal] Issue 4, pp. 324-329. Available through: RDC Publishing [13 August 2012].
IMAGES. (i) Tiller, D. 2008. *Greta oto - Glasswing*. [photograph] Available at: <http://en.wikipedia.org/wiki/File:Greta_oto.jpg> [Accessed 09 August 2012]. **(ii)** Unknown, 2008. Fig. 2 *Reflectance and transmission spectra of transparent area of G. oto wing over the wavelength range of 250-900 nm: a is the reflectance plot taken of the wing placed on a polished silicon wafer, and b is the transmission plot* [graph]. **(iii)** Unknown, 2008. *Fig. 3 SEM images showing scales and patterns on the surface og the G. oto wing:* ***a*** *a combination of flat anf piliform scales along a "vein" on the wing,* ***b*** *a combination of flat and piliform scales at the edge of the wing,* ***c*** *structure of the heart-shaped flat sclae and* ***d*** *oval shaped scales and the underlying pattern beneath the scales.* [SEM images]. (iv) Gringer, 2008. *Linear_visible_spectrum*. [image] Available at: <http://upload.wikimedia.org/wikipedia/commons/thumb/d/d9/Linear_visible_spectrum.svg/2000px-Linear_visible_spectrum.svg.png> [Accessed 07 September 2012].