Future Coating Designs for Enhanced Optics – Taking Lessons from Nature

B.T. Hallam[1] & P. Vukusic[2]

[1] IMERYS Minerals Ltd, Par Moor Road, Par, Cornwall, PL24 2SQ, UK
[2] Thin Film Photonics, School of Physics, University of Exeter, Stocker Road, Exeter, EX4 4QL, UK

ABSTRACT

Whiteness is a concept that carries considerable emotive power. Successful marketing campaigns have managed to convince us that brilliant whiteness is associated with increased purity, quality, freshness and cleanliness – making whiteness synonymous with enhanced brand value. As a result, whiteness is a desirable attribute in many common-place commercial products, such as: paper, plastics, rubber, ceramics and cosmetics. In these synthetic products, the inclusions of microscopic natural and synthetic mineral particles are used to provide the whiteness. The size and shape of these mineral particles are carefully controlled to ensure that they form packed structures that scatter light in a multi-wavelength manner, and with intensity that makes a firm visual impression. Through careful control of the size and PSD (particle size distribution), a great diversity of coating structures may be created in the complex mineral-void layer.

Traditional engineering has enabled this field to develop to a very high degree with increasingly complex beneficiation routes providing the ability to neutralise the shade of the mineral constituents, while the use of complex grinding and other mechanical routes have enabled mineral particle size and shape to be tailored with a high degree of control. However, a new approach is required to take this field further. Biomimetics provides one such approach. It is an enabling discipline that looks towards Nature for design inspiration, accepting that millions of years of design evolution may have provided novel and unique solutions to modern industrial problems.

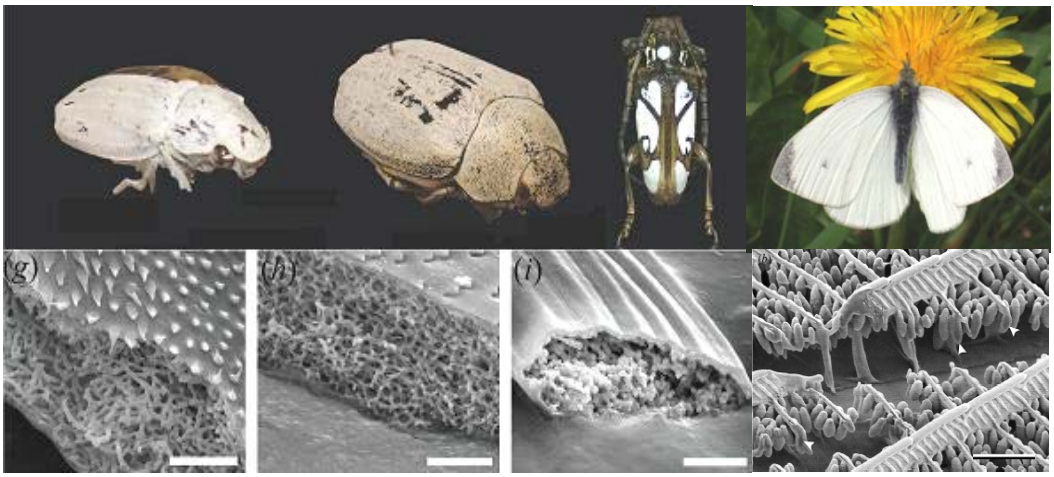

Figure 1: Nature provides a uniquely diverse set of architectures for producing whiteness

In this talk we draw inspiration from Naturally-occurring photonic structures to demonstrate how fabrication of novel micro-dimensional architectures may give rise to whiteness with an optical efficiency unmatched by synthetic substitutes. In

understanding such structures we start to develop a greater understanding of how we might mimic them in synthetic systems. Through this learning we have established firm design protocols that can improve the efficiency of mineral coating layers. While it is not currently economical to mass-produce exact replicas of the natural systems, it is possible to apply aspects of these architectures to provide real benefits in paper coating, opening the possibility of reduced cost to the Papermaker through de-materialisation and a more efficient weight/performance ratio.

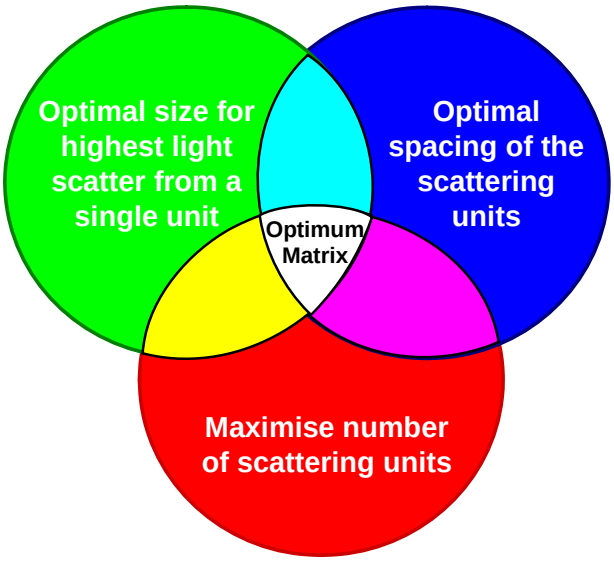

Figure 2: Optimal light scatter in mineral coatings requires a delicate balancing act of interdependent parameter.