Development of Biobased Pigments and Functional Materials

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Background and objective

The increasing interest in bio-based coatings, opens also up for a need of natural colorants, that can perform adequately in the harsh product conditions and comply with the long lifecycle of the products. Since most current natural colorants cannot yet live up to these requirements, in applications like paints, coatings, dyes or home care products synthetic colorants are still used. There is already a clear trend in the innovation space towards more sustainable and bio-based dyes in textile industry. In addition, nanoadditives such as Polyhedral oligomeric selsisquioxane (POSS) will provide additional functionalities to the biobased coating formulations. Focus will be to introduce fire resistance, strengthening UV-curing and hydrophobicity properties in the developed biocoatings (POSS), improve barrier properties (POSS) and tailor-make the rheological properties of formulations.

The overall objective is to develop and produce (i) new bio-based pigments of different colour and (ii) new functional nanomaterials or modifications of other coating components, for inclusion into coating formulations which can either improve coating performance or coating sustainability impact.

Biobased pigments developed at Chromologics

Chromologics has developed a new natural color, Atrorosins using a filamentous fungi. In Perfecoat Chromologics has further developed a laquer complex of atrorosin, coupling atrorosin to aluminum, make the new pigment Natu.Red complex.

Natu.Red Complex – a novel natural red pigment here tested in a white base paint, and in a clear coat.

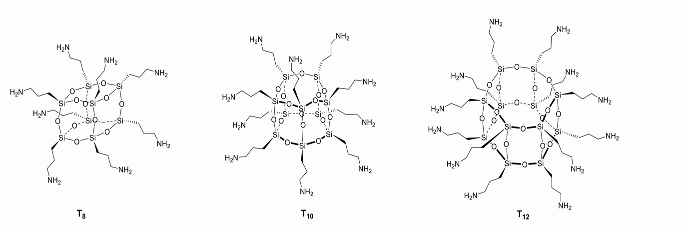
Chromologics proprietary filamentous fungi.

Atrorosin dye as produced from Chromologics proprietary filamentous fungi.

Functionalized POSS developed at SINTEF and Bioenvision

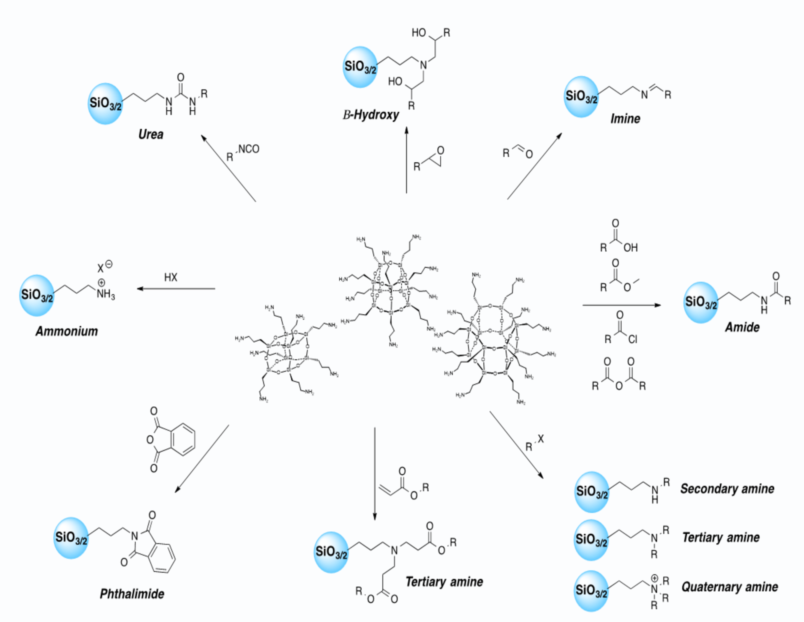
Synthesis of POSS – a two step synthesis

- 1st step: preparation of amino POSS via a controlled sol- gel process

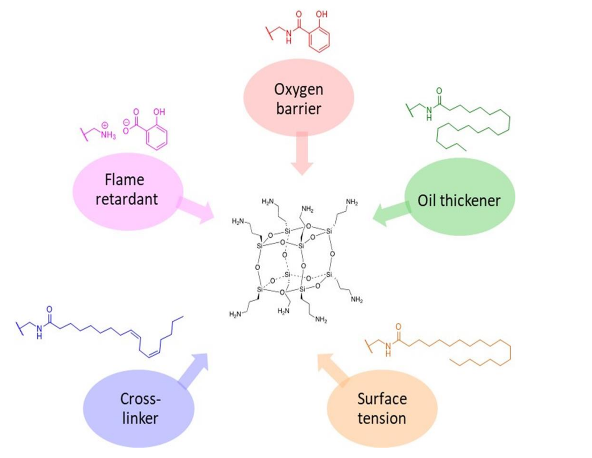


Well defined cage structure with size of of 2-3 nm

- 2nd step: Functionalization of amino POSS

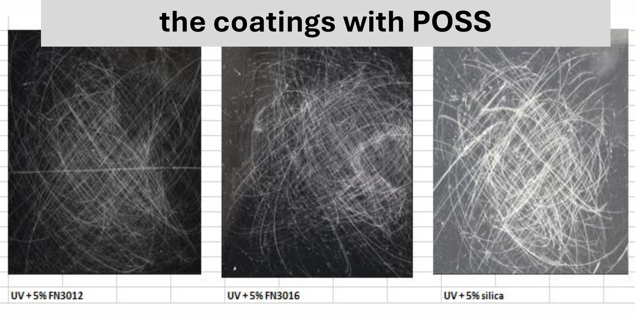


Potentials with POSS

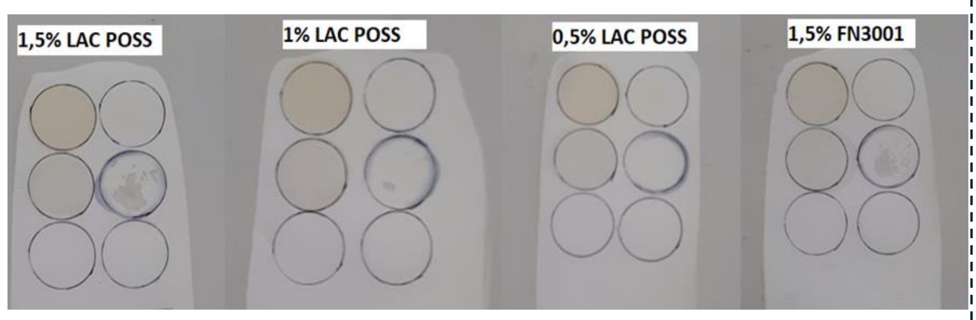


Functionalities in POSS can be designed and tailor-made for numerous properties and applications

Improvement of scratch resistance of the coatings with POSS



UV-curable wood coatings prepared at Evonik and tested after 50 rubs with a 3M abrasive disc with 5% POSS (FN03012, FN03016) and silica as additives.

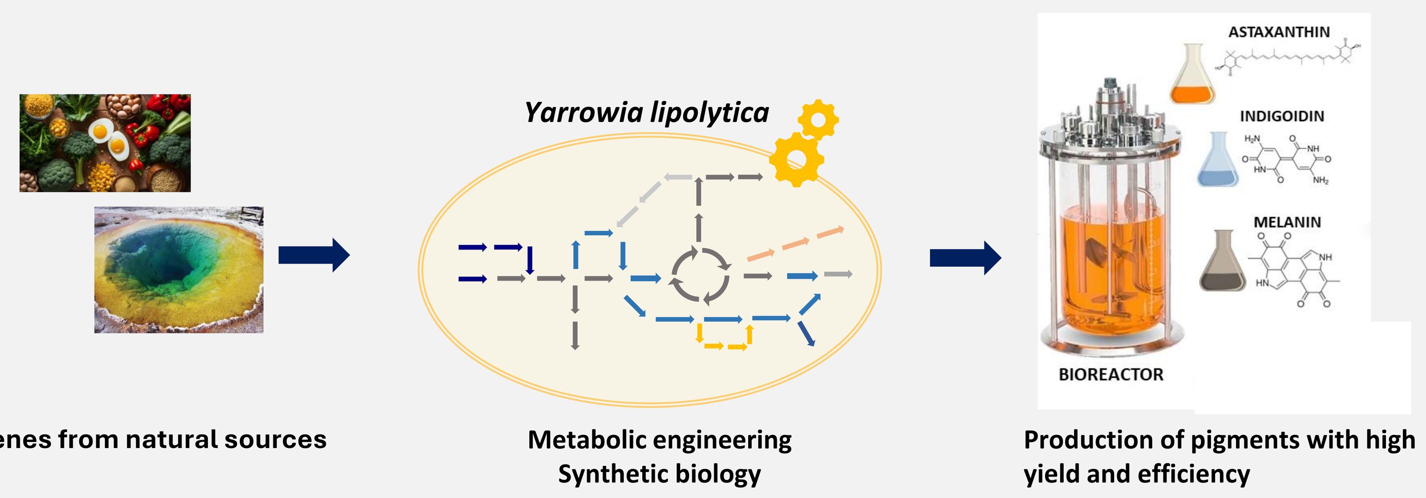


Preliminary testing results obtained by Organik Kimya showed Improved stain and chemical resistance after adding 0.5% LAC POSS in the coatings.

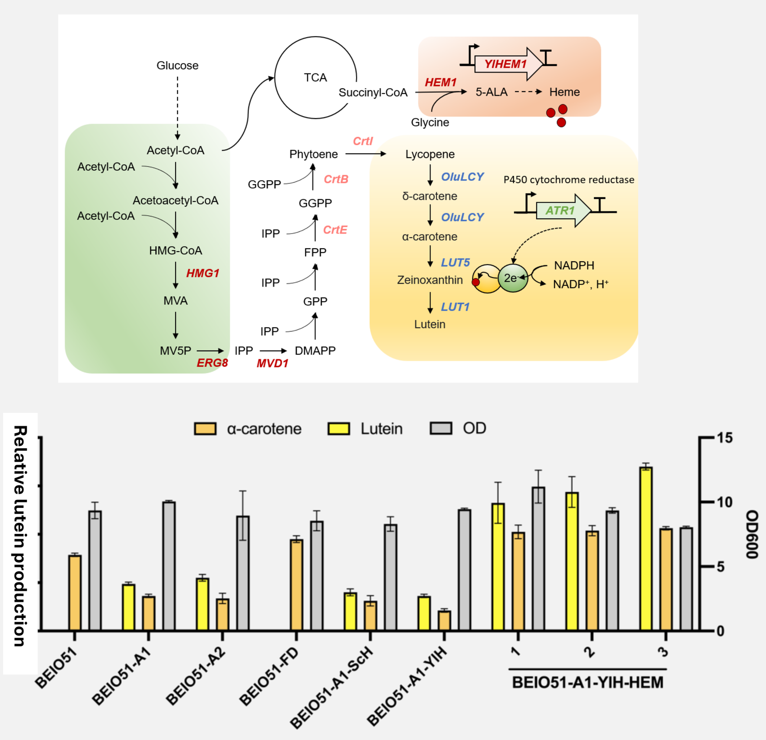
Biobased pigments developed at Imperial college London

Yarrowia lipolytica as an industrial host

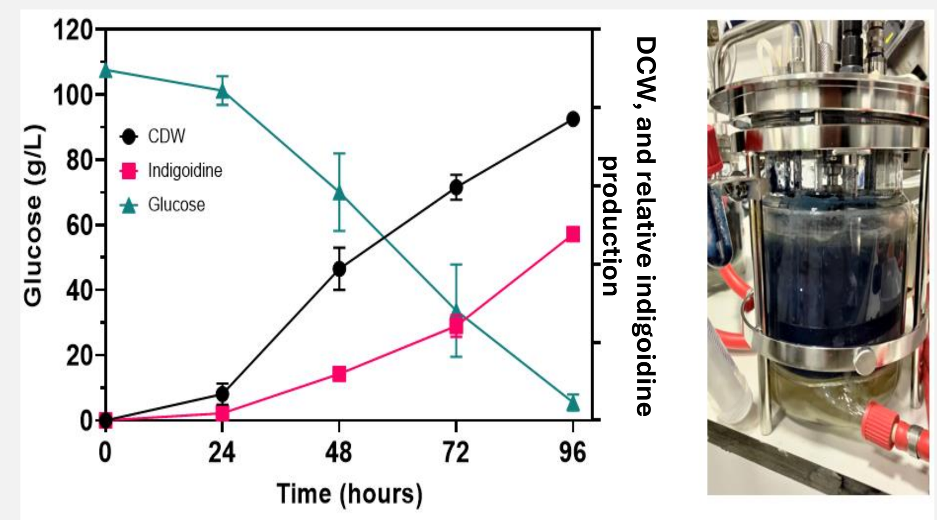
- Advantage: Robustness, stability, tolerance, safety, low-cost, high cell density, etc
- Weakness: oxygen requirement/foam generation, by product formation, insufficient fundamental knowledge, limited downstream process, etc.



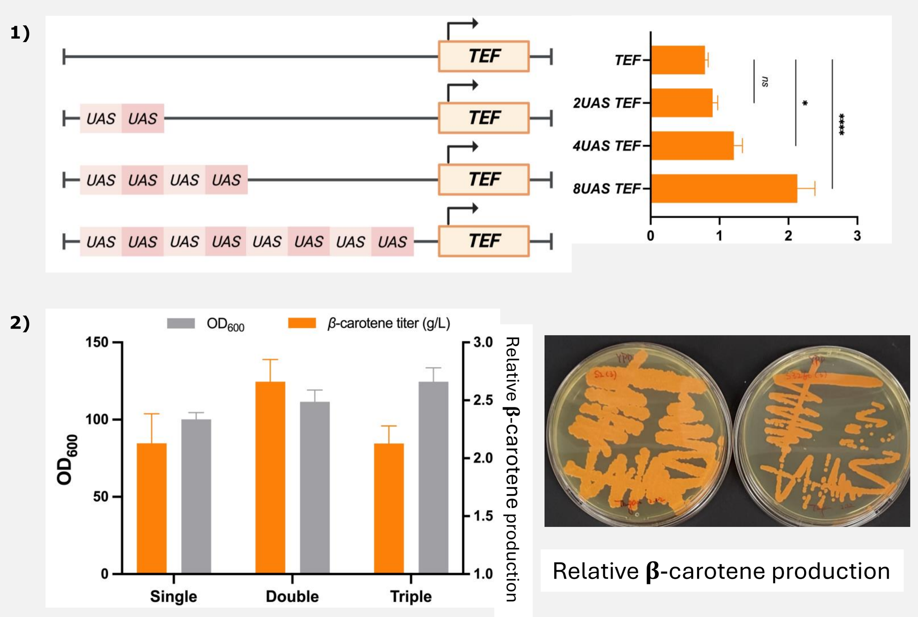
Pigment production in *Yarrowia lipolytica* by metabolic engineering and synthetic biology



Bioproduction of the yellow carotenoid lutein

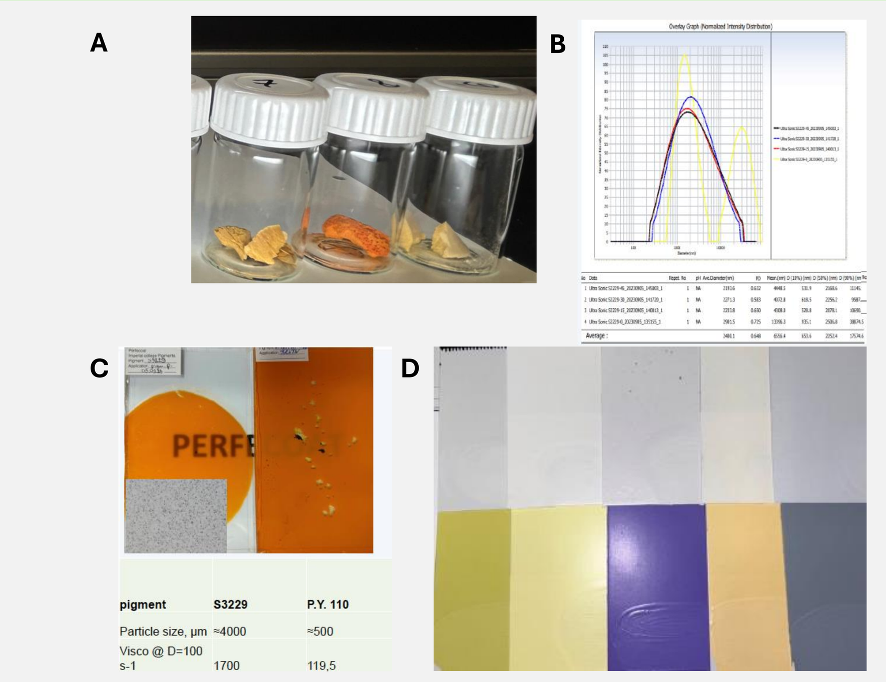


Production of the blue pigment indigoidine



The effect of promoter engineering (1) and gene copy number (2) on β-carotene production in *Y. lipolytica*.

Pigment samples made from *Yarrowia lipolytica* and its test as paint component



The use of pigmented freeze-dried yeast biomass as paint component. A – freeze dried yeast biomass; B – grinding power; C – hiding power; D – tinting strength.

- ICL engineered the yeast Yarrowia lipolytica for producing pigment compounds such as b-carotene (orange), lutein (yellow), violacein (violet), and indigoidine (blue).
- Various metabolic engineering strategies (introducing biosynthetic pathway, pathway engineering to boost precursor pools, modulation of gene expression by using hybrid promoter and copy number adjustment) have shown to improve the production of pigments as shown in the figures.
- The pigments from our biomass are under the analysis of their properties as painting by a collaboration with EVONIK in the PERFECOAT project.

Summary

- A novel red pigment has been developed from filamentous fungi and tested in coatings.
- Production of various biobased pigments have been evaluated and improved in the yeast Yarrowia lipolytica by synthetic biology and metabolic engineering.
- Several hydrophobic and hydrophilic POSS variations were developed. The additions of POSS in UV curable coatings and interior coatings showed enhanced scratch resistance and chemical stability.

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