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Innovative sustainable eco colourants for the textile industries



SOPHIED people



1 Colour... Reflection of our mood, society codes or personality...

Adding it on textile, plastic, cosmetic, man has never stopped inventing new processes to colour his life!

But are we really aware of their influence on health and environment? From the dyes and auxiliaries used for the dyeing and finishing yarns and fabrics, to energy greedy processes and polluted wastewaters, the colour industry impacts a significant impact on the health of customers and employees, as well as to the state of the environment.

The traditional colour chemical industry suffers now from displacement to the developing world due to increasing production related environmental costs as well as high labour costs in Europe. In addition, a range of dyes were shown to be toxic, mutagenic, allergenic, and there is a need to develop alternative safer molecules and processes. However, this sector is highly traditional and suffers from a very low research and innovation level.

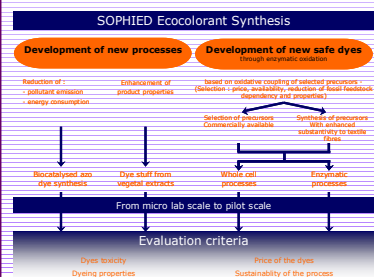
2 Issues to be faced to ensure a future sustainable economical development of the colour industry



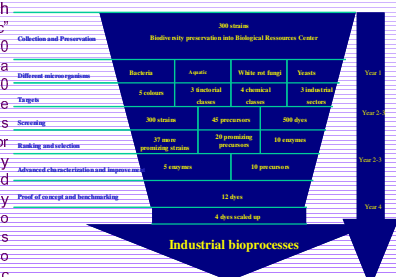
To face those issues, Sophied has combined a multidisciplinary approach at two levels:

1. New high added value ecocolourants safe for the health and for the environment for the textile sector.
2. Nanobiotechnological processes and systems to replace traditional harsh chemical synthesis.

3 Answers from SOPHIED



A screening of precursors led through "fungal biomass" or "enzymatic" bioconversions to the creation of 300 coloured molecules, amongst which a ranking led to the selection of 10 precursors and 5 enzymes. The mechanisms of Ecocolourants biosynthesis by whole cells or enzymatic bioconversions were deeply studied. Enzymatic processes showed to be generally more efficient and easy to handle. Some processes also led to improved extraction of coloured plants extracts (natural dyes), allowing to remove completely a mutagenic compound.



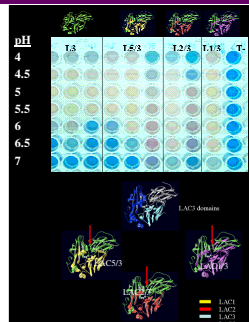
4 Collect of fungi and search of better enzymes

A collect of new White rot fungal strains was organised in French Guyana and in Cuba. They were screened for their ability to produce naturally coloured compounds and oxidative enzymes.



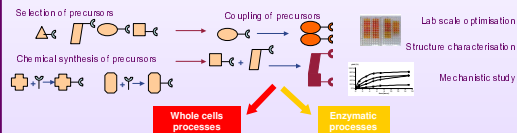
In order to get better enzymes with improved stability, wider pH range, more active, evolution engineering was undertaken:

- 9 Recombinant enzymes
- 5 hosts systems
- Evolution engineering
- Hybrid enzymes

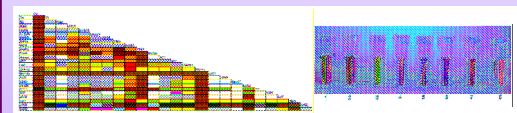


5 Screening of precursors

Chemical synthesis of original precursors with useful structural features for textile applications has been carried out and other precursors were selected among commercial chemicals.

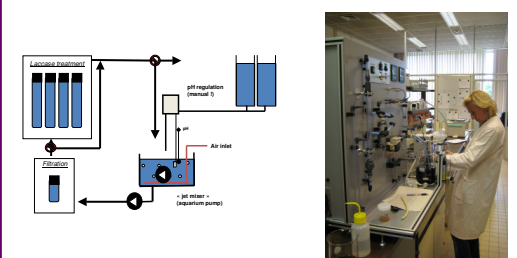


These precursors were submitted to the action of whole fungal living cells or to the action of laccase. Reactions were first optimised at lab scale, and structure characterisation of the most promising compound was undertaken.



- More than 300 of coloured reactions or culture media observed
- 15 dyes further developed
 - 5 red
 - 2 violet
 - 9 acid
 - 4 orange
 - 2 brown
 - 3 printing
 - 1 yellow
 - 1 green
 - 3 cosmetic

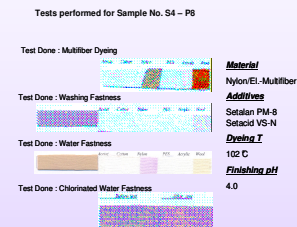
7 Up scaling



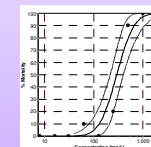
Through improved analysis four dyes were selected to be up scaled. Five pilot plants equipments were designed and constructed. A workshop was organised in Belgium in the presence of partners from Turkey, Italy, Poland to perform in three pilots a range of "statistical design of experiments" in order to optimize the enzymatic processes. Based on this, two industrial pilots were performed up to kg.

6 Industrial quality testing and toxicity testing

The 25 more promising dyes were tested for industrial quality (multifibre test, water colour fastness, perspiration fastness, washing fastness)...



... and toxicity (bacteria, human cells, fish cells, algae, Ames test...)



	LAB-1	Dyeing Red 1	Reductive Red 1	Direct Red 1	Acid Red 1
CAS No.	2572-52-8	1961-50-4	275-58-0	27741-47-6	
Caco-2 cytotoxicity test (EC50 in µg/L)	>1	>1	0.7 ± 0.06	0.3 ± 0.02	>1
Ames test mutagenicity	Negative	Negative	Negative	Positive*	Positive
Fish egg test (EC50 in mg/L)	294	250-500	500-1000	<30	250-500
Luminescence test % of luminescence inhibition at maximal OD	41.6 **	61.3 ***	25.9	3.4	50.2

10 non mutagenic dyes with proven low toxicity and potential industrial applicability were selected.

8 Proof of concept



As a "proof of concept", some items were made from Ecocolourants™ and natural dyes. Results were completed by a SWOT analysis (strengths, weaknesses, opportunities and threats), a costs analysis, and a LCA (life cycle assessment).

