ABSTRACT: The GREENER programme (submitted to the call FP7-NMP-2010-SMALL-4) is a collaborative project designed to further develop and implement a number of nanotechnologies leading to more sustainable and environmentally friendly alternatives to existing petroleum chemistry-based organic pigments, which face increasingly challenge due to their significant contribution to carbon emission and the gradual depletion of world crude oil reserve.

1. INTRODUCTION: Dyes and pigments are the essential ingredients for textile, printing inks, paint and coatings, and plastics industries. World demand for dyes and organic pigments is forecast to increase 3.9% per year to $16.2 billion in 2013, in line with real (inflation-adjusted) gains in manufacturing activity. In volume terms, demand will grow 3.5% annually to 2.3 million metric tonnes. Whilst dyes generally have more superior colour brilliance to pigments, organic pigments remain the dominant colorants for printing ink, paint and coatings and plastics industries due to their superior colour-fastness properties.

Due to the increasingly concerns in terms of carbon emission and gradual depletion of world crude oil reserve, there have been an increasing number of attempts in the development of pigments based on clays from natural resources. The advantages of nanopigment, in terms of both mechanical and optical properties, are well understood and documented. In terms of understanding the interactions between various dyes and nanoclays, significant advances have been made in the last few years, as a result of the intensive research carried out at the University of Leeds in collaboration with Core, and at the University of Alicante in collaboration with TNO (Netherland) and DyStar GmbH (Germany). However, it is also clear, through these studies that, a number of challenges still remain when attempting to expand the range of colour gamut. Such challenges include colour-bleeding, poor light-fastness and poor weather-resistance as compared to organic pigments, which have been the key barrier to the implementation of coloured nanoclays in industrial applications.
2. PARTICIPANTS

Table 1: List of participants

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<thead>
<tr>
<th>Participant no.</th>
<th>Participant Organization name</th>
<th>Country</th>
<th>Organization type</th>
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<tbody>
<tr>
<td>1</td>
<td>The University of Leeds</td>
<td>UK</td>
<td>Public University</td>
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<td>2</td>
<td>The University of Alicante</td>
<td>Spain</td>
<td>Public University</td>
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<td>Netherlands</td>
<td>Research Organization</td>
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<td>Spain</td>
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<td>8</td>
<td>METLA</td>
<td>Finland</td>
<td>Research Organization</td>
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<td>9</td>
<td>Nesil Co. Ltd.</td>
<td>Turkey</td>
<td>SME</td>
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3. GREENER CONCEPT - PROPOSED SOLUTION

The GREENER programme aims to further improve, develop and implement a number of nanotechnologies, already developed by members of the GREENER consortium, leading to more sustainable and environmentally friendly commercial pigment products based on coloration of nanoclays with a variety of dyes including natural, reactive, thermochromic, photochromic and electroluminescent varieties. Clearly, nanoclays will be employed as carriers for various dye molecules with an aim to improve performance properties including colour-bleeding, light-fastness, weatherresistance, and switching fatigue.

4. SCIENTIFIC AND TECHNICAL OBJECTIVES

The ultimate aim of the GREENER programme is to create technologies enabling the production of nanopigments in significantly more environmentally friendly ways using significantly more sustainable raw materials, in comparison with existing production technologies. In order to achieve such an aim, the GREENER programme intends to achieve the following objectives:

1. Preparation of nanopigments based on the use of nanoclays and selected natural and synthetic dyes.
2. Surface treatment technologies for nanoclays for improved fixation of dye molecules, also for colouring nanoclays and improving light-fastness, weather-resistance, fatigue cycle and dispersibility.
3. Applicability of the GREENER nanopigments in printing inks, paints and coatings.
4. Applicability of the GREENER nanopigments in photovoltaic devices.
5. Evaluation of the environmental impacts of the GREENER nanopigments.

7. PROGRESS BEYOND THE STATE-OF-THE-ART

The GREENER programme will take the state-of-the-art technologies in coloured nanoclays as a baseline and develop greener nanopigments beyond those currently exist.

5.1 Current state-of-the-art

Nanopigments based on coloured nanoclays have emerged in the last few years. Typical examples of nanopigments include the Planocolors®. In these cases, nanoclays have been proven good carriers for some organic dyes. However, a number of challenges remain including (i) strong covalent bonding could only be achieved for a limited number of synthetic dyes (thus limited type of dyes and range of colour available); and (ii) generally poorer light-fastness and weather-resistance compared to organic pigments. There is also a lack of speciality functional nanopigments and a lack of applications of clay-based nanopigments in printing inks, paints and coatings, and photovoltaic devices. There exist few reported studies on the environmental impacts of clay-based nanopigments. The feasibility of using coloured nanoclays in photovoltaic devices has not been thoroughly explored.

5.2 Advance beyond state-of-the-art through GREENER programme

1. Nanopigments based on nanoclays and natural dyes: The GREENER programme intends to extend research into the coloration of nanoclays with natural dyes, in an attempt to create nanopigments from sustainable/renewable resources.

2. Nanopigments based on different nanoclays and having a wider range of colours: The GREENER programme will build upon the existing knowledge that the consortium possesses to expand colour range of the nanopigments using nanoclays having different structural features and dyes of a wider colour gamut.

3. Speciality nanopigments: Functional dyes, such as photochromic and thermochromic dyes have found significant applications in the fields of healthcare (e.g. ophthalmic sun lenses which provide essential protection to the eye from the UV light component of sunlight), food safety monitoring (e.g. temperature-
time indicators for packaged foods, during production, storage, transportation and shelf-display), and security, anti-counterfeit and brand-protection (e.g. photochromic, fluorescent, thermochromic dyes used in printing security/anticounterfeit features on banknotes, in passports and brand protection logos). One of the more challenging problems is that most photochromic and thermochromic dyes have very poor light-fastness property, seriously restricting the application potential of such dyes. The immobilisation of such dyes on nanoclays will improve the light-fastness of the dyes, thus significantly enhancing the application values of such dyes.

4. Surface treatment technologies for nanoclay based pigments: Building upon the strength of the extensive experience of the consortium in surface treatment technologies for pigments, the GREENER programme will develop novel surface treatment technologies for both nanoclays and coloured nanoclays with an aim to improve the strength of bonding between the colorant molecules and the surface of the nanoclays, the light-fastness and weather-resistance of the nanopigments.

5. Understanding of the environmental impacts of nanoclay based nanopigments

6. Use of GREENER nanopigments in photovoltaic devices

7. Applications of GREENER nanopigments in inks, paints and coatings

The GREENER programme intends to develop coloured nanoclays with superior performance properties thus making it possible for the GREENER nanopigments to be used in a range of printing inks, paints and coatings products.

6. IMPACT: Expected impacts listed in the work programme

1. Strategic impact: The success of GREENER programme will have strategic impacts on the following aspects: (i) improving the technology of a number of industries (dyes, pigments, printing inks, paints, coating) and photovoltaic devices beyond the current state-of-the-art; (ii) contributing towards creating a tangible momentum in the application of nanotechnology in large scale industry, via a more sustainable and lower cost production process; and thus (iii) strengthening EU’s leading position in the implementation of nanotechnology and the conventional colour chemistry industries and its affine ones.

2. Enhancement of environmental sustainability of manufacturing processes: Successful outcomes of the GREENER programme will enable the production of nanopigments using more sustainable raw materials,
e.g. commercially available nanoclays, natural dyes, surfactants and polymers from renewable resources (e.g. those obtained through fermentation of biomass).

3. Promote the creation of markets for products and processes utilising “green nanotechnology”

4. Provide a significant contribution to the reduction on the demand of scarce or nonenvironmentally friendly raw materials elimination of use of hazardous substances in production processes and the reduction of non-eco waste material

7. CONCLUSION:

As a general conclusion, it can be said that GREENER involve a challenging cooperative work with great expectations in a wide variety of fields and directly focus on the future industrial application, such as textile, polymers, printing inks, etc. Furthermore, it involves the weave of a complex communicative net among participants. It is worth pointing out that this ambitious project gathers prospective targets, such as the improvement of life quality and the development of a highly competitive European industry, and strong environmentally friendly commitment and ethical values. Moreover, GREENER would provide a good chance to enhance and boost Europe and European institutions beyond competitors in the nanoscience and nanotechnology field.

REFERENCES: