Sustainable surface technology for multifunctional materials

Project name:
SurfaceT

Contract no.:
NMP2-CT-2005-013524

Instrument type:
STREP

Thematic Priority:
3

Start date
June 1, 2005

Duration
36 months

Total budget:
3.599.191 €

Funding from EC:
1.997.225 €

Contact person:
Dr. Concha Domingo
Project co-ordinator
conchi@icmab.es
ICMAB-CSIC
Campus UAB s/n
08193 Barcelona
Spain
tel: +34935801853
fax:+34935805729

Project participants:
CSIC (Spain)
CNRS (France)
Imperial College (UK)
UB (Spain)
FeyeCon (Netherlands)
MATGAS (Spain)
Gaiker (Spain)
EMCM (Netherlands)
Bactimm (Netherlands)
MECAM (Latvia)

Web site:
www.icmab.es/surfacet

Abstract

Biomaterials and drug delivery systems are complex composite systems, often made by applying toxic organic solvents. Technology based on supercritical carbon dioxide ($SCCO_2$) is an alternative to overcome those problems. Methods for surface control and tailoring on nanophase material is the main topic addressed in the project. The project is expected to accelerate transition towards a less intensive solvent-use industry. The advantage of $SCCO_2$ processing is that it cuts across many industries. The main goal of this project is the development of an innovative supercritical carbon dioxide (SCCO2) surface technology, applicable to existing and new high performance functional products. This should lead to procedures that enable the creation of complex surface structures, enabling the production of unique product characteristics in relation to composition, purity, and effectiveness.

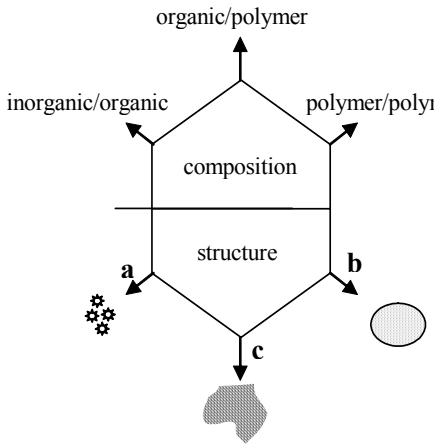
Objectives

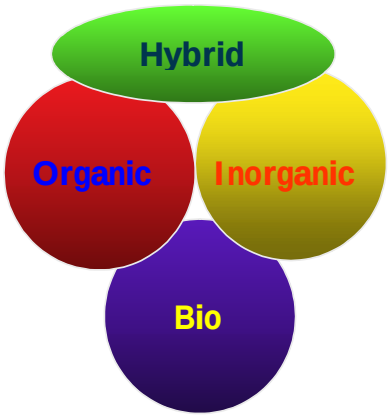
Preparation of functional composites by using the clean, integrated $SCCO_2$ surface technology. This project is focused on the processing of complex high value composite products starting from pharmaceutical and medical materials, like human bone structure, to solar cell particles coating. The processing of these composites has similarities with the processing of many other applications, ranging from neutraceuticals, cosmetics, reinforced plastics, or even self-cleaning and self-repairing plastics. All these possible applications have in common that the step of interface creation or surface modification in the preparation process is essential to achieve an end-product with the desired functionality. The specific measurable objectives are the following:

A. To develop a $SCCO_2$ surface technology that is able to produce complex structures and to improve product characteristics and effectiveness.
B. To engineer and scale-up the $SCCO_2$-processes for production.
C. To achieve a drastic reduction in waste generation.
D. To design existing/new materials for applications in biomaterials/pharmacy.
E. To design existing/new materials for applications in pigments and plastics.
F. To convey the knowledge from researchers to manufacturing industries.

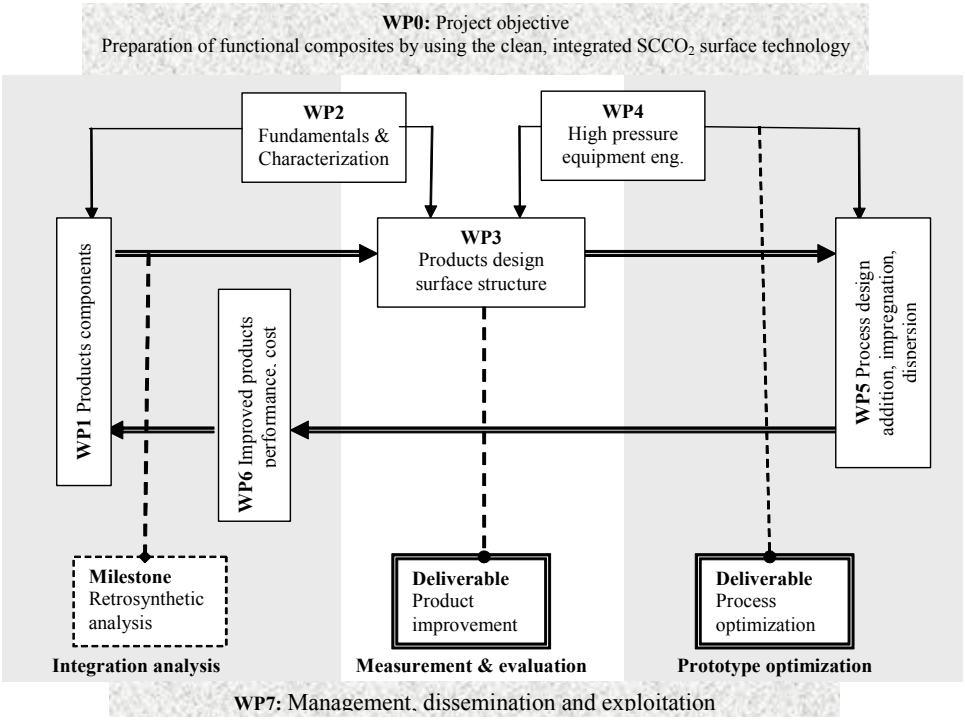
Technical approach

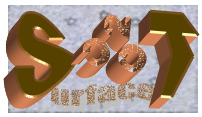
The project starts with processing simple basic materials and continues towards the design and production of multifunctional products. The project will present bottom-up production routes and possibilities of using the technology as part of the production-line. Fields of applications are mainly related to biomaterials, pigments and plastics. In these fields composite products will be designed. The composite materials will be either organic (organic/polymer and polymer/polymer) or hybrid (inorganic/organic). Several structures will be produced: (a) surface modified particles, (b) internal impregnated porous systems, and (c) dispersed materials in a polymer matrix.





The project is divided into seven workpackages. The realization of the proposed main goal is based on a retrosynthetic analysis: for each finished product, the possible ways in which it can be produced using $SCCO_2$ technology will be deduced. All workpackages are initiated by the project objective (WP0). The project cycle starts with specifying the requirements of the products and its components (WP1). To characterize the products performance, a firm knowledge of the raw materials and their mutual interaction is needed. This is achieved through WP2, where both theory and analysis are addressed. With the knowledge of the raw materials and the design specifications the product structure can be designed (WP3). After that, the high pressure equipment needed for manufacturing the desired product is specified (WP4). In WP5, the products are made using $SCCO_2$ technology. Finally, improved product quality made by the developed $SCCO_2$ technology will be demonstrated and an economic evaluation will be made (WP6). The management (WP7) principally orchestrates the project cycle and communication, but also advises in the dissemination of results and technology implementation.





Expected project achievements

$SCCO_2$ is a non-destructive solvent adequate to manipulate complex functional materials and nanostructures. Furthermore, the technology allows obtaining end-products free of residual solvents. $SCCO_2$ technology is proposed here for the production of a great range of knowledge-based multifunctional materials with better control of surface properties and purity, and for the industrial -high-rate, high-volume- fabrication of surface hybridized or composite materials. By developing the technology, breakthroughs will come not only from the method but also from the new products. On the basis of chosen materials and techniques that have advantages to be used for certain products, a methodology will be developed considering the following relationships: *material characteristics ⇔ desired properties ⇔ classes of $SCCO_2$ processes⇔ product performance.* This will provide decision criteria applicable to different family of products:

1. Pharmaceutical industry. *The problem*: organic solvent use in the production of drug systems, which form toxic traces. *Expected achievement*: $SCCO_2$ does not have the drawback of forming contamination traces in drugs. Encapsulation and surface coating/impregnation processes aided by SCCO2 with direct applications envisioned for the pharmaceutical industry.

2. Biomaterials. *The problem*: research in soft and hard tissue engineering lead to the conclusion that porous polymers and polymers composites are the most suitable compounds to mimic natural material functions. In general, the production of porous polymers is solvent intensive. *Expected achievement*: more sustainable alternatives based in $SCCO_2$, since compressed CO_2 is a versatile wetting agent due to their low surface tension and low viscosity for internal surface modification.

3. Materials for industries using composites: plastics, pigments, zeolites, concrete, etc. Developed equipment and processes will be used to show that SCCO2 technology is a cross-cutting technology that can be applied to different industrial fields. Hence, the coating, impregnation and dispersion processes will be applied to the development of advanced composite materials.

Plan for using and disseminating the knowledge

$SCCO_2$ technology has been around for several years, but commercialization has been limited to food and textile processing. The potentials of the $SCCO_2$ technology (clean, fast, flexible, and non destructive and compact) remain unrealized, because of various obstacles that hinder its implementation and market penetration: industry lacks awareness of the potentials of $SCCO_2$ technology, replacement of current "matured technology" by insecure technology (risk aversion), insufficient controlled evidence that CO_2 processes lead to added value products, lack of the expertise, etc. Besides the normal research dissemination tools (interactive web resources, publications, participation in conferences, congresses, etc.) special dissemination activities will be organized to transfers new methods to important European industries, enabling them to create added value processes and products.

To increase the potential impact in a shorter period, the exploitation policy will set-up two technological platforms:

1. Platform for the biomedical, pharmaceutical and cosmetic industries
2. Platform for composite materials

Each platform will be constructed to perform the following services: i) core data for industry specific development tools, ii) technical infrastructure: reliable technology, iii) economical model, and iv) legal regulations.