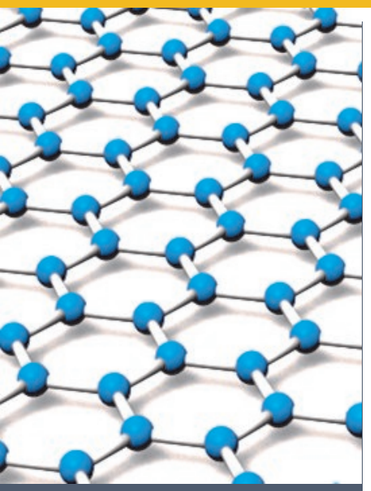


- Graphene is composed of carbon atoms arranged in tightly bound hexagons just one atom thick.
- Three million sheets of graphene on top of each other would be 1mm thick.
- In 2004, teams including Andre Geim and Konstantin Novoselov demonstrated that single layers could be isolated, resulting in the award of the Nobel Prize for Physics in 2010.
- It is a good thermal and electric conductor and can be used to develop semiconductor circuits and computer parts.

Main objectives

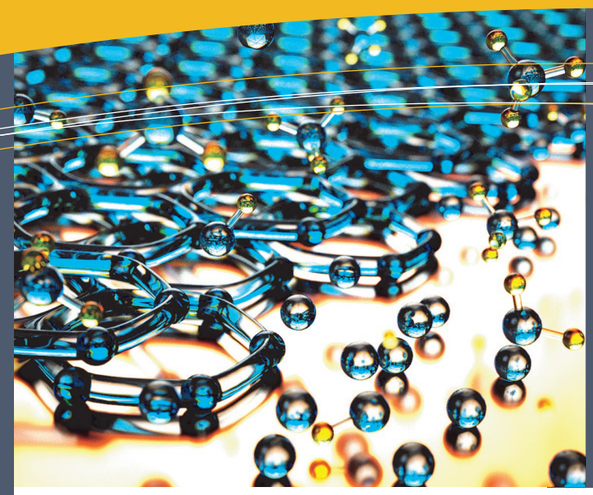
- ✓ Synthesize innovative, cheap and non-hazardous materials (TiO_2-graphene composite photocatalysts) that can be employed to establish a sustainable water and wastewater treatment method, based on solar driven heterogeneous TiO_2 photocatalysis for the degradation of emerging organic pollutants (such as pharmaceuticals), thus reducing the energy fingerprint of the Euro-Mediterranean basin.
- ✓ Prevent the deterioration of water quality and promote the sustainable management of water resources, thus facilitating the implementation of Water Framework Directive and the protection of inland waters and seawater, including flora, fauna and potentially human beings from xenobiotics.
- ✓ Bridge the gap between laboratory scale research and technical scale application demonstrating the proposed method of solar photocatalysis in a pilot unit.
- ✓ Promote the cooperation of the involved research institutions and the small enterprise that have significant experience in the specific field, thus safeguarding high level work, both in terms of research and technology.
- ✓ Communicate and disseminate the project objectives, methodology, findings and new insights obtained. The project results are expected to contribute to the implementation, update and development of environmentally friendly practices and policies and to the incorporation of environmental research to decisions related to sustainable development in Cyprus.

REPUBLIC OF CYPRUS
STRUCTURAL FUNDS of the European Union in Cyprus
our ideas, actions for development
EUROPEAN UNION
Research Promotion Foundation
ΔΕΣΜΗ 2009-2010
Θέλω στο μέλλον.

The PhotoGraph (ΑΕΙΦΟΡΙΑ/ΑΣΤΙ/0311(ΒΙΕ)/33) project is co-funded by the Republic of Cyprus and the European Regional Development Fund

PhotoGraph

ΑΕΙΦΟΡΙΑ/ΑΣΤΙ/0311(ΒΙΕ)/33



Beneficiaries

University of Cyprus

NIREAS-International Water Research Center

Technical University of Crete

S.K Euromarket Ltd

this issue

Photocatalytic Removal of Organic Micropollutants from the Aqueous Phase using TiO_2 coupled with Graphene as a Photocatalyst

Pollution of aquatic bodies by trace pollutants has become a major environmental problem. A great number of these compounds, at the ng L^{-1} to the μg L^{-1} level (often referred to as micropollutants), have been detected in various compartments of the aquatic environment worldwide. This indicates the ineffectiveness of the widespread currently most frequently applied conventional biological treatment processes to remove adequately such compounds from the domestic wastewaters.

Accordingly, advanced treatment processes may be necessary to provide further reduction of these compounds, in order to minimise environmental and human exposure.

Advances in chemical water and wastewater treatment led to the development of a range of processes termed advanced oxidation processes (AOPs). Heterogeneous photocatalysis is a catalytic process occurring on the surface of semiconductor materials under the irradiation of photons. By far the most researched photocatalyst is TiO_2, because it exhibits several advantages, such as high photocatalytic efficiency, photochemical stability, non-toxicity and relatively low cost.

At present, there are three major drawbacks of heterogeneous TiO_2 photocatalysis that restrict its practical application:

(i) the rather small (<10%) quantum yield of the process, resulting from the fast electron/hole recombination; (ii) the relatively narrow light-response range of TiO_2 and (iii) the need of post-separation and recovery of the catalyst particles from the reaction mixture in aqueous slurry systems.

In this respect, the aim of the present project is to employ novel composite photocatalysts with enhanced photocatalytic activity, such as TiO_2 coupled with graphene, simple and efficient methods for synthesizing TiO_2 catalysts coupled with graphene, and to study their photocatalytic performance under solar radiation for the degradation of various emerging organic pollutants, thus opening up new opportunities in next generation photocatalyst systems.

Graphene has been chosen because it is a new interesting material with exceptional properties, isolated for the first time in 2004.

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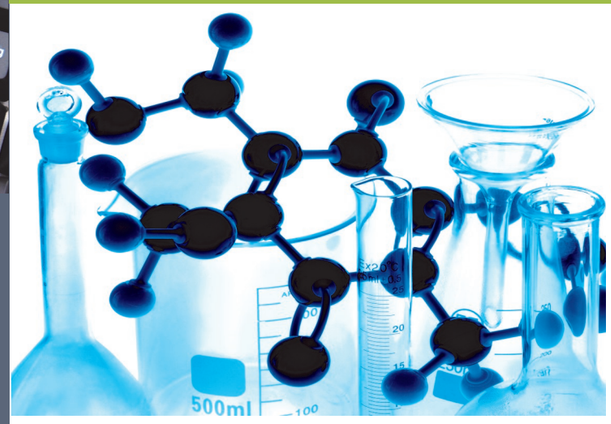

Work packages

WP1: Project management and coordination of the project

- Establishment of a Steering Committee
- Monitoring of the technical and economic progress
- Preparation of Deliverable reports, Interim and Final Reports

WP2: Dissemination of Results

- Creation of project website
- Publications in internationally accredited relevant scientific journals
- Participation in national-international conferences
- Organization of a workshop at national level
- Publications of articles to Greek and Cypriot press

WP3: Synthesis of TiO_2-reduced graphene oxide composite photocatalysts

- Synthesis of TiO_2-reduced graphene oxide composite photocatalysts and optimization of important preparation conditions
- Application of three different methodologies for the reduction of graphene oxide (GO) and the simultaneous formation of TiO_2-RGO composite catalysts:
  - ✓ Photocatalytic method
  - ✓ Hydrothermal method
  - ✓ Microwave method

WP4: Characterization of the synthesized photocatalysts and toxicity measurements

- Characterization of the synthesized photocatalysts in terms of particle and surface properties using various techniques
- Toxicity evaluation of the synthesized photocatalysts using bacterial species (*Enterococcus* sp. & *Staphylococcus* sp., *Escherichia coli* and *Klebsiella* sp.) and an aquatic organism (*Daphnia magna*)

WP5: Testing photocatalytic efficiency of the TiO_2-RGO catalysts for the degradation of emerging organic pollutants

- Evaluation of the photocatalytic efficiency of the synthesized TiO_2-RGO catalysts under simulated solar radiation by measuring the degradation of a mixture of four organic pollutants in aqueous solutions
- Comparison of the relative photocatalytic activity of the various catalysts synthesized by implementing a two-level factorial design and optimization of the important preparation conditions

WP6: Design, setup and operation of a bench scale pilot treatment unit

- Design, setup and operation of a bench scale pilot treatment unit, operating in a continuous mode, consisting of a photochemical reactor and a cross-flow micro-filtration system for the recovery and reuse of the catalyst
- Screening of various commercially available microfiltration membrane modules (polymeric ceramic membranes)
- Study of the various parameters affecting the performance of the treatment unit and finding the optimum operating conditions