Research Group n. 2
UNIVERSITY OF CATANIA

Heterogeneous Catalysis for Environmental and Industrial Applications

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Research activity

The research activity is mainly focused to the preparation and characterization of heterogeneous catalysts and photocatalysts with special interest devoted to their applications in the fields of environmental protection and energy production, focusing on sustainable materials and processes.

Main research topics

- *Advanced photocatalysts for green technologies*

Photocatalysis was applied successfully to several processes, including hydrogen production, decomposition of organic pollutants both in air and in water and more recently reduction of carbon dioxide. We focused on the improvement of the photocatalytic performance of semiconductor oxides (as TiO_2 and CeO_2) by joining them to noble metal nanoparticles or other oxides, and modifying their structure by introduction of defects or formation of a peculiar porous structure.

- *Catalytic removal of Volatile Organic Compounds (VOC) over gold based catalysts*

This topics deals with the effect of preparation and pretreatment approaches towards the performances of gold catalysts in the VOC combustion. Interesting results were obtained on Au/CeO_2 and Au/Fe_2O_3 systems, which showed a high combustion activity, related to the capacity of gold to weaken the surface Ce-O or Fe-O bonds adjacent to Au atoms, enhancing the reactivity of the capping oxygens of the oxide, involved in the VOC oxidation through a MvK mechanism.

- *Hydrogen production through $NaBH_4$ hydrolysis over supported Ru catalysts*

Polymer electrolyte membrane fuel cells (PEMFC) are among the most advanced systems for energy production starting from H_2. Nowadays hydrolysis of hydrides is receiving special attention as ideal source of pure H_2 for PEMFC, specially for portable applications. In this context we are investigating the hydrolysis of $NaBH_4$ and NH_3BH_3 over supported Ru nanoparticles, focusing on the effect that different variables can have on the Ru particles size and their catalytic performance.

- *Hydrogen purification through preferential oxidation of CO (PROX)*

Selective oxidation of CO in H_2-rich stream (known as PROX reaction) is regarded as one of the most promising technology to reduce CO concentration to acceptable levels for fuel cells applications. We deal with the use of IB metal/ceria and Pt/zeolite catalysts in the PROX reaction, with the aim to enlighten the role played by both the metal and the support in affecting the chemico-physical properties and therefore the performance of the catalytic system.

- *Smart design of sustainable and efficient ionic liquids (ILs):*

Optimization of ILs properties is presently a major goal of scientific research, which has to take also into account ILs human hazard potential, their effects on aquatic ecosystems and economic considerations. Our studies addressed not only ILs efficiency for specific applications, but also their environmental and economic sustainability. We derived ILs *in silico* descriptors suitable for Quantitative Structure Property-Relationships (QSPR) models allowing property prediction for unknown ILs before planning their synthesis and carrying out efficiency and toxicity tests.

Key words: Heterogeneous catalysis, Photocatalysis, Green chemistry, Energy, Hydrogen, Nanoparticles, Ionic liquids

Recent Publications

- S. Scirè, L. Palmisano, *Cerium Oxide (CeO_2): Synthesis, Properties and Applications*, in Metal Oxides Series, Elsevier, (2020). https://doi.org/10.1016/C2017-0-02724-6 ISBN: 9780128156612
- R. Fiorenza, L. Spitaleri, A. Gulino, S. Sciré, "High-Performing Au-Ag Bimetallic Catalysts Supported on Macro-Mesoporous CeO_2 for Preferential Oxidation of CO in H_2-Rich Gases*"* Catalysts 10(1) (2020) 49.
- R. Fiorenza, S. Scirè, L. D'Urso, G. Compagnini, M. Bellardita, L. Palmisano, *"*Efficient H_2 production by photocatalytic water splitting under UV or solar light over variously modified TiO_2-based catalysts*"*, Int. J. Hydrogen Energy 44 (2019) 14796-14807.
- R. Fiorenza, M. Bellardita, S. Scirè and L. Palmisano, "Photocatalytic H_2 production over Inverse Opal TiO_2 catalysts", Catalysis Today 321-322, 113-119 (2019).
- R. Fiorenza, S. Scirè, A. Gulino, "Ru-Pd bimetallic catalysts supported on CeO_2-oxides as efficient systems for H_2 purification through CO preferential oxidation", Catalysts, 8, 203, (2018).
- R. Fiorenza, M. Bellardita, S. Scirè, L. Palmisano, "Effect of the addition of different doping agents on visible light activity of porous TiO_2 photocatalysts", Molecular Catalysis 455, 108-120 (2018).
- R. Fiorenza, M. Bellardita, T. Barakat, S. Scirè, L. Palmisano, "Visible light photocatalytic activity of macro-mesoporous TiO_2-CeO_2 inverse opals", J. Photochem. Photobiol. A: Chem., 352, 25-34 (2018).
- R. Fiorenza, S. Scirè, A.M. Venezia, Carbon supported Ru-Co bimetallic catalysts for the H_2 production through $NaBH_4$ and NH_3BH_3 hydrolysis, Int. J. Energy Research 42, 1183-1195 (2018).
- A. Paternò, C. Bonaccorso, C.G. Fortuna, G. Musumarra, S. Scirè, "Data-Driven Modelling of Gas Solubility in Ionic Liquids Using Principal Properties as Orthogonal Descriptors", ChemistrySelect 3, 2181-2184 (2018).
- A. Paternò, S. Scirè, G. Musumarra, Smart design of sustainable and efficient ILs, in Ionic Liquid Devices, Ali Eftekhari Ed., RSC, Chapter 7, pp. 168-197 (2018).
- L. D'Urso, S. Spadaro, M. Bonsignore, S. Santangelo, G. Compagnini, F. Neri, E. Fazio "Zinc oxide nanocolloids prepared by picosecond pulsed laser ablation in water at different temperatures" EPJ Web of Conf. 167, 04008 (2018).
- S. Filice, G. Compagnini, R. Fiorenza, S. Scirè, L. D'Urso, M.E. Fragalà, P. Russo, E. Fazio, S. Scalese**,** "Laser processing of TiO_2 colloids for an enhanced photocatalytic water splitting activity", J. Colloids and Interfaces Science 489, 131-137 (2017).
- K.O. Iwu, A. Lombardo, R. Sanz, S. Scirè, S. Mirabella, "Facile synthesis of Ni nanofoam for flexible and low-cost non-enzymatic glucose sensing", Sensors and Actuators B: Chemical 224, 764-771 (2016).
- L. D'Urso, S. Santangelo, S. Spadaro, S. Scibilia, A.M. Mezzasalma, F. Neri, E. Fazio, " Enhanced optical response of ZnO/Ag nanocolloids prepared by a picosecond laser", J. Luminescence 178 204-209 (2016).
- R. Fiorenza, M. Bellardita, S. Scirè, L. Palmisano, "A comparison between Catalytic and Photocatalytic oxidation of 2-Propanol over CeO_2 doped TiO_2-based catalysts" J. Mol. Catal. A, 415, 56-64 (2016).
- G. Ognibene, D.A. Cristaldi, R. Fiorenza, I. Blanco, G. Cicala, S. Scirè and M.E. Fragalà, "Photoactivity of hierarchically nanostructured ZnO-PES fibre mats for water treatments", RSC Advances, 6, 42778-42785 (2016).
- R. Fiorenza, C. Crisafulli and S. Scirè, "H_2 purification through preferential oxidation of CO over ceria supported bimetallic Au-based catalysts", Int. J. Hydrogen Energy 41, 19390-19398 (2016).
- R. Fiorenza, M. Bellardita, L. D'Urso, G. Compagnini, L. Palmisano, S. Sciré, "Au/TiO_2-CeO_2 catalysts for photocatalytic water splitting and VOC's oxidation reactions", Catalysts, 6, 121 (2016).

SUPPLEMENTARY MATERIAL

Position of the components of the Research Groups

Name	Surname	Position *	Affiliation
Salvatore	Scirè	PA	Università di Catania
Roberto	Fiorenza	RU (RTDA)	Università di Catania
Stefano Andrea	Balsamo	S (PhD)	Università di Catania
Giuseppe Romano	Compagnini	PO	Università di Catania
Luisa	D'Urso	RU (RTI)	Università di Catania
Marcello	Condorelli	PoD	Università di Catania

*: PO = Full professor; PA = Associate professor; RU = University researcher; CO = contract; PoD = Postdoctoral fellows; RC = CNR staff or other Institutions Research; T = technician, VR = visiting researcher, S = student

Equipment

Type	Producer	Year of acquisition
TG-DTA	LINSEIS STA PT-1600	2006
FT-IR	PERKIN ELMER SYSTEM 2000	1998
BET SURFACE AREA	THERMOQUEST SORPTOMATIC 1990	1995
GC	THERMOFINNIGAN TRACE GC	2003
GC	AGILENT HP 6890 SERIES	2000
RAMAN	WITECH ALPHA 300 RS	2014
PULSED LASER Nd:YAG	CONTINUUM SURELITE II	2003

Technical skills

- Preparation of heterogeneous catalysts by various approaches
- Catalytic and photocatalytic tests in liquid and gas phase
- Characterization of nanomaterials and catalysts (TPR, FT-IR, RAMAN, XPS, XRD, TGA/DSC, BET surface area, chemisorptions)
- Pulsed laser ablation in water