



HAL
open science

Graphene/TiO₂ photocatalysts synthesis by laser pyrolysis for ethylene production

Juliette Karpel, Pierre Lonchambon, Frédéric Dappozze, Nathalie Herlin,
Chantal Guillard

► **To cite this version:**

Juliette Karpel, Pierre Lonchambon, Frédéric Dappozze, Nathalie Herlin, Chantal Guillard. Graphene/TiO₂ photocatalysts synthesis by laser pyrolysis for ethylene production. SPEA11 - 11th European Conference on Solar Chemistry and Photocatalysis: Environmental Applications, Jun 2022, Torino, Italy. . cea-03695961

HAL Id: cea-03695961

<https://hal-cea.archives-ouvertes.fr/cea-03695961>

Submitted on 15 Jun 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

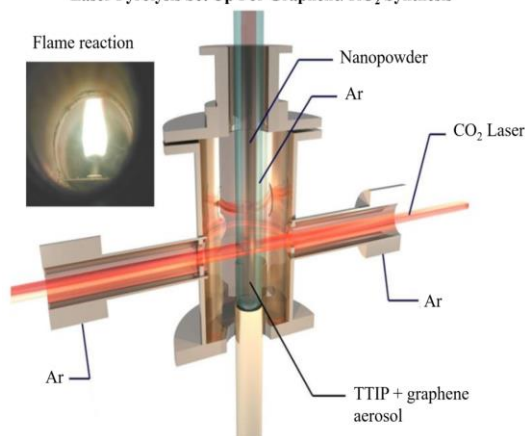
L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Graphene/TiO₂ Photocatalysts Synthesis By Laser Pyrolysis For Ethylene Production

will be filled in by SPEA11

Juliette Karpie^{1,2}, Pierre Lonchambon¹, Frédéric Dappozze², Nathalie Herlin¹, Chantal Guillard² (1) University of Paris-Saclay, CEA, CNRS, NIMBE, Gif-sur-Yvette Cedex, France. (2) University of Lyon 1, IRCELYON, CNRS, Villeurbanne, France. juliette.karpie@cea.fr

Laser Pyrolysis Set Up For Graphene/TiO₂ Synthesis



In an effort to produce alkenes in a low-cost and less energy-consuming way, this study presents the possibility of a photocatalytic process permitting to obtain ethylene from propionic acid.

To this end, TiO₂ and graphene/TiO₂ photocatalysts were successfully synthesized by an original method, the laser pyrolysis technique. Consisting on an interaction between a CO₂ laser beam with liquid/gaseous precursors, this process provides great flexibility in terms of crystallinity, nanoparticles size etc. The obtained nanocomposites were mostly composed of anatase and graphene could be detected with RAMAN spectroscopy.

TiO₂ and graphene/TiO₂ were compared for ethylene photo-production from propionic acid, and ethylene yield did not seem to be significantly improved despite graphene addition.

Alkenes, and more particularly ethylene C₂H₄, are essential organic molecules for chemical and petrochemical industries and are needed in ton quantities [1]. New ways to produce ethylene without hydrocarbons are developed. They mainly focus on ethanol dehydration reaction. However, despite the use of heterogeneous acid catalysts, these processes require high temperatures reaching 200-550°C and consequent pressures, at least 0.3 MPa and consequently correspond to significant energy consumption [2-3].

In this context, we aim to synthesize environmental-friendly and low-cost photocatalysts, which could degrade organic compounds such as alcohols and acids into alkanes and alkenes at ambient temperature and atmospheric pressure. Particularly, the outcome sought here is to promote high selectivity and yield towards ethylene photo-production using UVA as energy source.

To achieve this goal, graphene modified TiO₂ nanostructures appear to be promising photocatalysts for their high stability, excellent electron mobility and large specific surface area [4-5].

Thus, TiO₂-based photocatalysts were synthesized from TTIP (Titanium Tetra Isopropoxide) precursor by an original gas-phase method, the CO₂ laser pyrolysis technique. This one-step method consists on an interaction between an infrared laser beam with gaseous and/or aerosolized liquid precursors. Such process, existing at industrial scale, offers a great flexibility in obtaining small and homogeneous nanoparticles (5-60 nm size ranging), with controlled

crystallinity and carbon content. Addition of graphene (Graphene Nano Pellets - GNP, 120-150 m²/g) in TTIP allowed obtaining graphene-modified TiO₂ composites (from 0.04 to 2.00 wt% regarding TTIP). Nanopowders were thus synthesized with a production rate of several grams per hour.

Obtained graphene/TiO₂ nanocomposites were mostly formed of anatase (>95 wt%), indicating a low-temperature laser pyrolysis flame preserving graphene nanosheets from heat destruction. Moreover, GNP graphene could be detected by RAMAN spectroscopy. Graphene/TiO₂ specific surface area tends to increase with graphene content.

These photocatalysts were first used for photo-oxidation of formic acid solutions. At low graphene loadings, results shew slight improvements in formic acid degradation compared to bare TiO₂. Besides, the composites were also tested for alkene photo-production from 1 vol% of propionic acid photo-reduction. Subsequent photo-Kolbe reaction permits producing CO₂, ethane, ethylene, butane and H₂. Graphene/TiO₂ exhibit no significant ethylene production enhancement whatever graphene content. For both photocatalysts graphene-TiO₂ and associated TiO₂ reference, ethylene selectivities and yields remained low.

To conclude, graphene/TiO₂ photocatalysts were successfully synthesized by laser pyrolysis. Despite slight improvements for formic acid degradation at low graphene loadings, these nanocomposites presented no significant differences in results compared to pristine TiO₂ for ethylene photo-

production from propionic acid.

In a further work, graphene oxide will be considered in order to promote the anchorage of TiO₂ on graphene nanosheet.

Keywords: Photocatalysis, TiO₂, Graphene, Ethylene.

References

- [1] J. Sattler, J. Ruiz-Martinez, E. Santillan-Jimenez, B. Weckhuysen, *Chem. Rev.* 114 (2014) 10613–10653.
- [2] A. Tresatayawed, P. Glinrun, B. Jongsomjit, *International Journal of Chemical Engineering* (2019) 1–11.
- [3] V. Coupard, N. Touchais, S. Fleurie, H. Gonzales Penas, P. De Smedt, W. Vermeiren, C. Adam, D. Minoux, *WO 2013/050669 AI* (2013).
- [4] S. Morales-Torres, L. M. Pastrana-Martinez, J. L. Figueiredo, J. L. Faria, A. M. T. Silva, *Environ Sci Pollut Res.* 19 (2012) 3676–3687.
- [5] K. Wang, M. Endo-Kimura, R. Belchi, D. Zhang, A. Habert, J. Bouclé, B. Ohtani, E. Kowalska, N. Herlin-Boime, *Materials*, 12 (24) (2019) 1–19.