ENVIRONBOS Report Summary

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Final Report Summary - ENVIRONBOS (Isolation, Characterization and screening of environmental applications of Bio-Organic substances obtained from urban biomasses (EnvironBOS))

The EnvironBOS Project (Isolation, Characterization and screening of environmental applications of Bio-Organic substances obtained from urban biomasses) has, as scientific objective, to explore possible environmental applications of soluble bio-organic substances (SBO) isolated from the humid fraction of urban wastes in order to achieve valorization of a residue to be used for further environmental applications. In particular, their potential use in (solar) photochemical wastewater treatment processes seemed promising as they show analogous chemical composition as humic substances, which have been recently used for these purposes. Furthermore, they can also be employed as auxiliaries for the synthesis of new materials of environmental interest.

The process employed to isolate the SBO starting from organic urban refuses consists in an anaerobic or aerobic microbiological treatment of the organic fraction which is further extracted (briefly, the soluble fraction at basic pH was extracted to be finally isolated by posterior precipitation at acidic media). The process has been scaled up to obtain amounts of SBO of several kg per week. Different types of SBO have been obtained, depending on the starting materials which have been used for their isolation. The products have been characterized. Main functional groups have been determined as well as the major metal ions which can be found. These materials are relatively resistant to (photo)-oxidative conditions. Regarding to their biological properties, these compounds can be classified as non-toxic and poorly biodegradable. This makes this materials compatible for environmental applications when used at low concentrations (typically below 100 mg/L)

The ability of SBO to act as photosensitizer in the elimination of pollutants has been investigated. Irradiations have been performed with UVC, UVA-visible light and with real sunlight. Among the pollutants that have been studied are chlorophenols, dyes, pharmaceuticals and pesticides. Results indicate that the mechanisms involves generation of different oxidative species: for instance, singlet oxygen might be predominating at high BOS concentrations (typically 1 g/L) and hydroxyl radicals play a more important role at low amounts of this material (a few mg/L). The possible involvement of triplet states of BOS cannot be disregarded although the system is too complex to obtain reliable data based on photophysical measurements. Nonetheless, the real applicability of BOS as photocatalyst is limited by several drawbacks: a) the screen effect produced by these highly coloured materials and b) their role as scavengers of the reactive species that are photochemically formed.

A more realistic approach for wastewater treatment is their use as complexing agents of iron for the implementation of photo-Fenton processes at milder conditions. SBO contains in their composition some amounts of iron (between 0.15 and 0.8% w/w, depending on the type SBO); hence upon addition of hydrogen peroxide a photo-Fenton process occurs in some extent, even at neutral pH. The process is highly enhanced by the addition of some amounts of iron (in the range 1-5 mg/L) and at a slightly acidic media (pH = 5). Experimental design methodologies have been applied in order to determine the effect of different operational parameters on the efficiency of the process and to optimize the experimental conditions. Results have demonstrated that a SBO concentration of ca. 20 mg/L, an iron amount of ca. 4 mg/L and a concentration of hydrogen peroxide slightly above the stoichiometrically required are able to drive an efficient photo-Fenton at pH= 5

Furthermore, SBO has been investigated as synthesis precursor and/or as active phase in the preparation of various materials, in particular oxides but also metallic particles: oxidic monoliths formed by silica and titania nanoparticles; TiO_2 powders, Fe_3O_4 stabilized in nanometric size by SBO, SBO-Fe_3O_4 samples, SBO immobilized on siliceous supports, or Ag nanoparticles. These materials have been fully characterized Some of these materials have been tested as photocatalysts under UV or visible irradiation or studied as adsorbing materials to remove metals from solutions.

Finally some work has been performed on the use on other technical application of BOS: a) in textile dyeing processes and their potential application on the treatment of the generated pollutant, b) as surfactants in order to improve the stability of emulsifiers employed in the metal-mechanic industry or c) to study its interaction vs. nanoparticles, such as carbon nanotubes.

Different multidisciplinary courses have been implemented based on the project a) a monographic course on SBO implemented in April of 2012 at the University of Torino; b) a course on environmental photochemistry was given at the Technical University of Valencia, c) a similar course was held at La Plata, during May-June 2012. Another course was repeated in Torino in June 2013 and different conferences were given by the professors during their visits. This presentations were announced and open to stakeholders which might be interested in the project. A final workshop with the participation of most of the people involved in the project took place in La Plata during July 2014.

In this moment, 13 research papers have been published in relevant journals and some more are now being prepared, one monographic book on the results of the project, involving all 5 universities has been accepted by Springer and will be publisehed soon, and three dissemination articles are now being prepared to be published in professional journals, in Portuguese, Italian and Spanish. Furthermore, the results have been presented at the different specialized congresses.

Finally the PhD thesis of four students are mainly based on the results of the project and those of other three are also partly related with the environBOS project.

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