Abstract

The research of new eco-friendly technologies that enable the production of energy is nowadays one of the topics of greatest interest to the scientific community. The population has chosen to break free from the use of fossil fuels, and this leads to the study and development of processes for the production of clean energy starting from biomass. However, at the same time, the concern of the industry is also the disposal and treatment of wastewater.

Starting from these considerations, it is advisable to develop processes that, under mild conditions, allow to obtain interesting hydrogen or methane yields. This objective could be achieved through the use advanced oxidation processes (AOPs), such as heterogeneous photocatalysis, photo-Fenton like reaction and photoelectrocatalysis.

So, an interesting approach is to explore, in parallel to wastewater treatment, the possibility to produce also an energy source such as hydrogen and/or methane from the degradation of organic substance present in wastewater by AOPs.

Considering the characteristic of food industries wastewaters, it is interesting to evaluate the performances of advanced oxidation processes for their treatment aimed to the valorization, through the conversion of specific substances (sugars), in order to obtain compounds with high energetic value, but also for removing substances hardly biodegradable (such as food dyes) that could be present in these industry wastewaters.

In this PhD thesis it has been studied the performances of the photocatalytic process for the hydrogen production from food industries wastewaters. In particular, starting from synthetic solution containing glucose, it was evaluated the effect of the presence of noble metals on the semiconductor surface and the effect of the photoactive support (TiO_2).

Subsequently, providing for the application of heterogeneous photocatalysis to industrial level, the study has been directed to the formulation of a noble metal free photocatalyst with good performances in the production of hydrogen and in the degradation of the sugars present in the solutions. The final formulation was represented by $LaFeO_3$ (a perovskite with semiconducting properties) prepared by combustion flame method. To improve the performances under visible light, $LaFeO_3$ was modified with Ru (Ru-$LaFeO_3$), whose cost is much lower than those of Pd, Pt or Au.

Always perspective of the application of the process to industrial level, it was developed a structured photocatalyst for solving the problems related to the photocatalyst separation after the treatment. In particular it was studied the efficiency of magnetic Fe_2O_3 as support for Ru-$LaFeO_3$.
It was also investigated the photoelectrocatalytic process for the hydrogen production, considering the general aspects of the process, the advantages and in particular the attention has been focused on the electrodeposition process for the synthesis of Fe_2O_3 based photoanodes.
Finally, the aim has been the application of the photocatalytic process on a real wastewater coming from the washing process of the fruit (especially cherries).
It was not underestimated the presence of food dyes in these types of wastewater. For this reason it was evaluated the efficiency of photo-Fenton process in the removal of several food dyes (such as Red Allura and Tartrazine) using $LaFeO_3$ deposited on corundum monoliths.
In addition, it has been evaluated the possibility to couple the photocatalytic process (used for the valorization of the wastewater through the production of hydrogen) to the optimized photo-Fenton system to completely remove the not-biodegradable substances still present in the wastewaters recovered after the photocatalytic treatment using Ru-$LaFeO_3$ supported on magnetic Fe_2O_3 particles.