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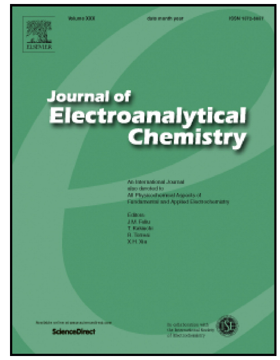

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Photoelectrochemical and photocatalytic systems based on titanates for hydrogen peroxide formation

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Abstract
The development of efficient, sustainable, cheap and safe methods for the synthesis of hydrogen peroxide is a very important challenge from the environmental viewpoint, since H_2O_2 can be used as a solar fuel or for degradation of organic, inorganic and biologic pollutants from wastewater. Efficient photocatalytic or photoelectrochemical formation of hydrogen peroxide from water and/or oxygen in an acidic medium has been obtained using nickel or cobalt titanates under visible light illumination. The concentration of H_2O_2 achieved in the photoreaction reached ~~as high as~~ 2.5 mM when nickel titanate was irradiated for 1 h in oxygen saturated suspension. In such conditions, $NiTiO_3$ provide active sides for both, oxygen reduction and water oxidation leading to H_2O_2 formation.

Introduction
Conversion of solar energy into easily storable chemicals has recently attracted considerable attention as strategic technology to provide a clean energy. Photoelectrochemical hydrogen production from water or photocatalytic carbon dioxide reduction to methane are considered as some of the most promising approaches for solar energy utilization [1,2]. The use of hydrogen peroxide (H_2O_2) as an alternative solar fuel is also very promising since the reduction of oxygen to H_2O_2 is thermodynamically more favorable than reduction of H^+ towards formation of hydrogen [3]. Moreover, H_2O_2 presents several great advantages in comparison with H_2 as a fuel [4]. It is liquid at room temperature and atmospheric pressure thus it has higher energy density and can be stored, transported and used without a high-pressure tank. The theoretical open circuit potential of the H_2O_2 fuel cell is 1.09 V [5], by consuming hydrogen peroxide as both an oxidant at an anode and a reductant at a cathode [6] according to:

$$H_2O_2 \rightarrow O_2 + 2H^+ + 2e^- \text{ (0.68 V vs NHE)} \qquad (1)$$

$$H_2O_2 + 2H^+ + 2e^- \rightarrow H_2O \text{ (1.77 V vs NHE)} \qquad (2)$$

The open circuit potential is thus just slightly lower than that of a hydrogen/oxygen fuel cell (1.23 V [6]).

Moreover, H_2O_2 is a clean oxidant, with water as the only byproduct. In industry, it is commonly used for pulp bleaching as well as for disinfection due to its antimicrobial activity [7].