EUROPACAT

FLORENCE, ITALY **2017**

27 - 31 August

THURSDAY, 31 AUGUST 2017

AUDITORIUM - PALAZZO CONGRESSI

TS4.1

EUROPACAT FLORENCE 2017
27th - 31th August
A BRIDGE TO THE FUTURE

Photoelectrochemical abatement of arsenic in water by hematite photoelectrodes

Davide Spanu,[a] Francesco Malara,[b] Andrea Turolla,[c] Alberto Naldoni, [b] Manuela Antonelli, [a] Sandro Recchia, [a] Vladimiro Dal Santo[b,*]

[a] *Dipartimento di Scienza e Alte Tecnologie, Università dell'Insubria, Via Valleggio 11, 22100 Como, Italy.*

[b] *CNR - Istituto di Scienze e Tecnologie Molecolari, Via Golgi 19, 20133 Milano, Italy.*

[c] *Politecnico di Milano, DICA - Environmental Section, Piazza Leonardo da Vinci 32, 20133 Milano, Italy.*

**Corresponding author: v.dalsanto@istm.cnr.it*

Arsenic is considered as one of the major issues among drinkable water pollutants because of its widespread distribution and its low acceptable limits. The most widely used removal technology involves arsenic adsorption on iron oxides, but this process is more effective for As(V). Since in groundwater arsenic is usually present as As(III), a preliminary oxidation treatment is often required to get high abatement yields. Moreover, despite it is a cheap and effective technology, adsorption generates a contaminated bed that must be disposed as toxic waste or regenerated by expensive techniques. Aiming at solving such problems, we are developing an alternative process involving a one-pot photoelectrochemical in situ oxidation and adsorption. Hematite nanostructured photoelectrodes showed promising performances by achieving almost complete abatement of arsenic from aqueous solutions under simulated solar light irradiation, in the view of economic and environmental sustainable application.

1. Scope

Arsenic is a highly toxic pollutant of drinking water. Accepted limits for total arsenic concentration are as low as 10 $\mu g L^{-1}$, according to EU regulations[1]. Traditional removal processes include: oxidation, coagulation/filtration, adsorptive media, ion exchange and reverse osmosis. Since it is more difficult to adsorb As(III) rather than As(V), the adsorption on iron oxides beds requires the preliminary oxidation to arsenate anion. This process has some drawbacks, such as the use of chemical oxidants and the disposal of exhausted beds as toxic waste or their regeneration with expensive processes. Here we will provide the proof of concept for an alternative and more sustainable approach based on photoelectrochemical adsorption and oxidation. Hematite-based photoelectrodes proved to be active in the oxidation of As(III) to As(V) under visible light irradiation, reaching almost complete removal of arsenic according to the required limits.

2. Results and discussion

Hematite films deposed on FTO glass were obtained by a straightforward controlled precipitation procedure[2] leading to rod-like nanostructures, as reported in Figure 1. Such a simple method allowed preparing photoelectrodes up to 25 cm^2 surface.

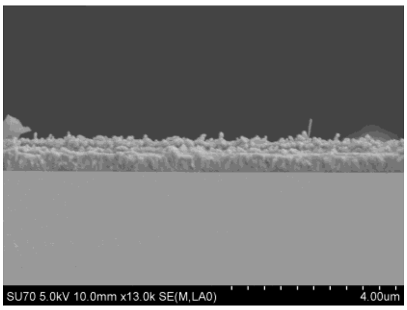

Figure 1. SEM of hematite/FTO photoelectrode cross section.

First arsenic abatement tests, performed in a standard 3 electrodes photo-electrochemical cell, 1 SUN AM 1.5 irradiation, pH 10, with a bias of 700mV (vs RE Ag/AgCl), showed promising results: around 80% of arsenic was removed from water in less than 24 h (see Figure 2).

Preliminary kinetics studies suggest the occurrence of a pre-adsorption step followed by a first order kinetics.

Besides the slow abatement rates, these preliminary results represent an important proof of concept, since the feasibility of a one-step photo-electrochemical abatement of As(III) under visible light irradiation was demonstrated.

Research work devoted to improve abatement performances (i.e., higher abatement rates) is under development; it involves both the optimization of materials photoelectrodes and the design of a suitable photoelectrochemical reactor. Finally, it is worth to underline two advantages of our approach: (1) hematite photoelectrodes are based on a cheap, widely available and non-critical raw material, such as iron; (2) utilization of solar light as main energy input. These two points well fit the grand challenge “Catalysis for a cleaner and sustainable future”.

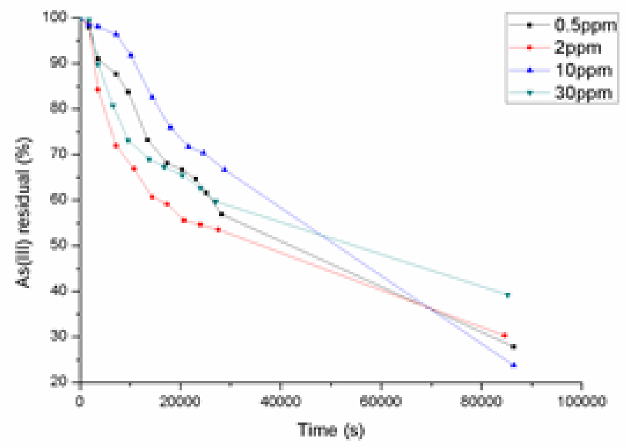

Figure 2. PEC abatement of As(III) solutions at different concentrations (0.5 – 30 ppm).

3. Conclusions

Our findings represent a proof of concept for the feasibility of photo-electrochemical one-step abatement of arsenic in water using hematite-based photoelectrodes under solar light irradiation. TiO_2 based systems, represent benchmark in photocatalytic cleantech processes[3], but they are active only under UV irradiation. Therefore, the development of alternative materials, such as hematite, which are active under solar light irradiation and are based on non-critical raw material, is one of the cutting-edge research topics in catalysis science.

References

1. EUROPEAN UNION (DRINKING WATER) REGULATIONS STATUTORY INSTRUMENT No. 122 of 2014.

2. F. Malara, A. Minguzzi, M. Marelli, S. Morandi, R. Psaro, V. Dal Santo, and A. Naldoni, *ACS Catal.*, **2015**, *5 (9)*, 5292–5300.

3. S.H. Hwanyoon and J.H. Lee, *Environ. Sci. Technol.*, **2005**, *39*, 9695-9701.