CYSS
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Development of a novel and improved UVA-photoelectrochemical reactor for wastewater treatment

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Introduction

Photoelectrocatalysis (PEC) technology, combining Photocatalysis (PC) and electrochemistry, is a potential solution for the degradation of organic pollutants in wastewater. PEC overcomes the high electron/hole recombination in PC process. Several PEC reactors based on TiO_2 photoanodes have been designed with different geometries and configurations. However, these different designs are still under study at a lab-scale. Challenges to be addressed include the design of PECs which give a high surface area of irradiated photoanode under back-face irradiation, with low cell resistance and high surface area of an appropriate counter electrode.[1]

Objective

The aim of this study is to optimize and evaluate the geometry of a scalable novel PEC reactor which utilizes TiO_2 on ITO glass as the photoanode under back-face UVA irradiation to generate hydroxyl radicals. Different counter electrode materials will be investigated to maximize the production of reactive oxygen species through the electrochemical reduction of molecular oxygen.

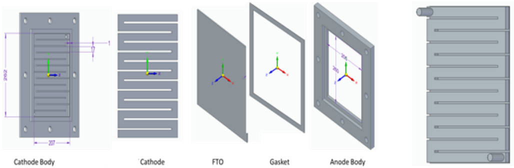
CFD Modelling

CFD was used to evaluate the mean residence time and effect of PEC cell geometry including inlet pipe diameter, inlet flow, and channels width on the flow velocity and regime inside the reactor. CFD simulation conditions considered were laminar/turbulent fluid flow, fluid viscosity and density, inlet flow velocity and the reactor outlet pressure. The physics interface Equation solved using CFD is:

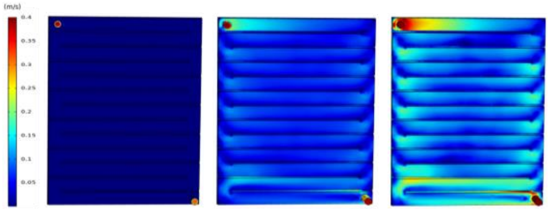
Navier-Stokes equation [2]:

$$\rho\frac{\partial \mathbf{u}}{\partial t} + \rho(\mathbf{u}\cdot\nabla)\mathbf{u} = \nabla\cdot[-p\mathbf{I} + \mu(\nabla\mathbf{u} + (\nabla\mathbf{u})^T)] + \mathbf{F}$$

$$\rho\nabla\cdot\mathbf{u} = 0$$

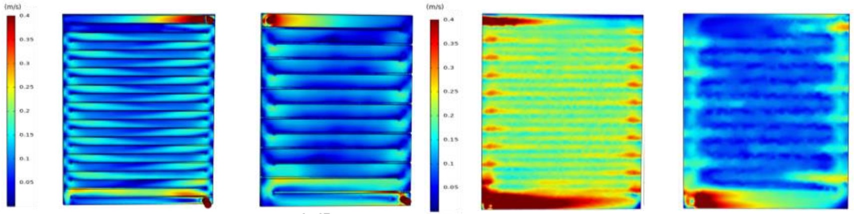


Effect of inlet flow rate on the velocity inside the channels



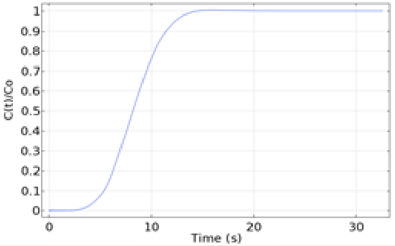
	Q (ml/s)	Re	P drop (Pa)
a	10	1411	48.4
b	30	4233	415
c	60	8467	1424

Effect of channel width on the flow velocity inside the channels



Front side back side

Mean residence time



Conclusions and Future Work

No difference was found by changing the inlet pipe diameter but decreasing the channel width inside the reactor resulted in increasing the fluid velocity, as expected.

The next steps will be to evaluate the degradation of model pollutants in the reactor using both UVA blacklight blue Hg lamps and UVA LEDs for irradiation.

Acknowledgements
Authors would like to thank the funds received by the European Union under the Marie Skłodowska-Curie Actions (Call: H2020-MSCA-ITN-2018; Project N. 812574)

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[2] C. Multiphysics, CFD Module User 's Guide. 2016. 598.

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