Organic Semiconductors in Photo-electrocatalysis for Solar Energy Conversion into Synthetic Fuels

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Organic semiconductors can be used for conversion of solar energy not only into electricity (organic photovoltaics) but also into synthetic fuels by means of CO_2 recycling.
This can be also regarded as an efficient way to store the renewable energy in form of chemical fuels.

The catalytic centers and molecules can be directly and chemically built into the semiconducting polymers enabling them to perform different catalytic actions within one and the same electrode. Such bulk catalytic organic semiconductor electrodes will be used for producing synthetic fuels such as syngas, methane, methanol and higher hydrocarbons.

A schematic decsription of such an "Photoelectrocatalytic System" using organic semiconducting electrodes is displayed in Fig. 1.

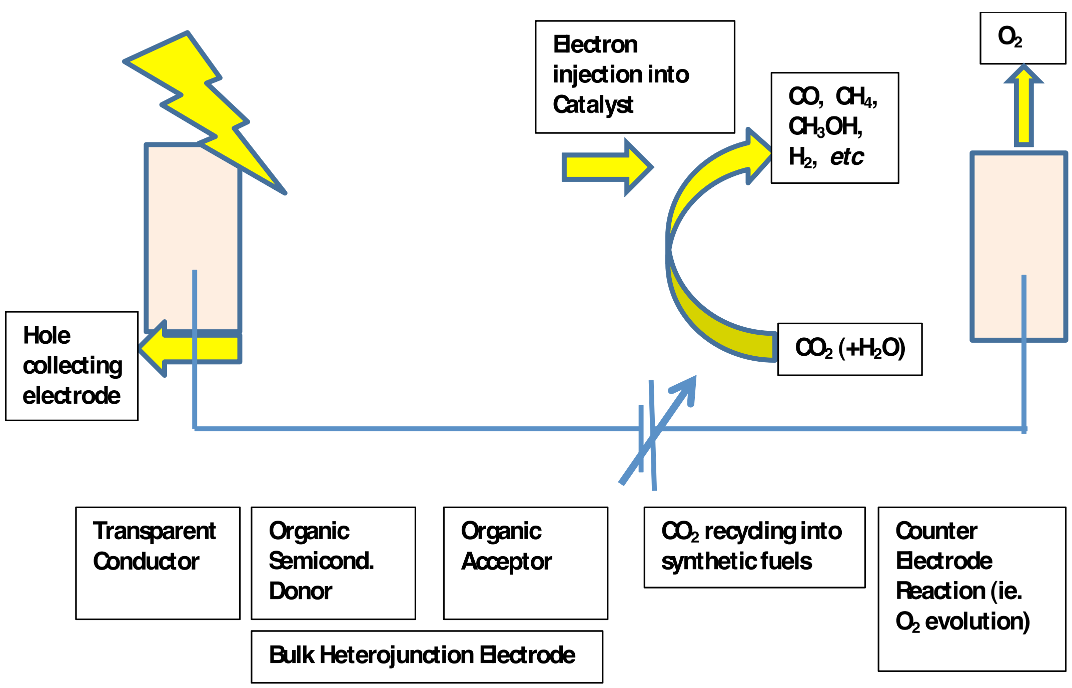

Fig.1: Schematic description of a photoelectrochemical system using organic bulk heterojunctions

In our recent work we utilized an organic semiconductor as light absorbing donor material in combination with an acceptor catalyst, as for example Pyridinium[7] or (2,2'-bipyridyl)Re$(CO)_3$Cl, for the actual CO_2 reduction.

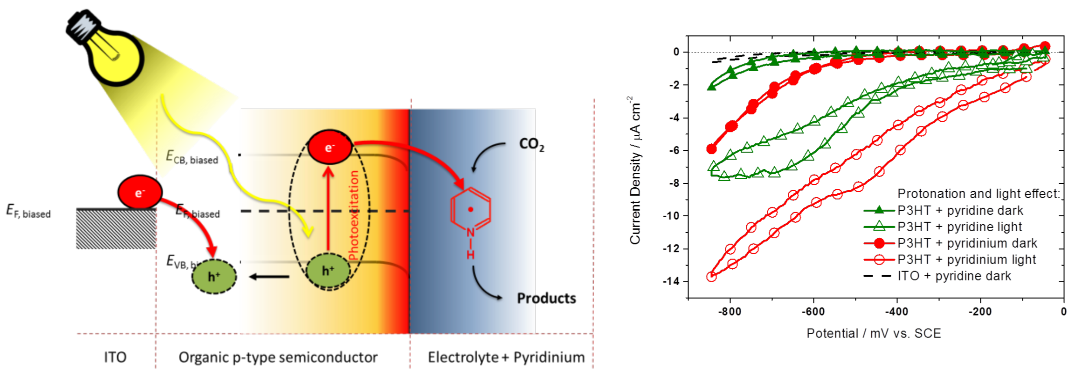

Fig.2 Left: Schematic description of the P3HT electrode with pyridinium homogenous catalyst. Right: The observed cyclic voltammograms in dark and under light

With Gas Chromatography we could show the occurence of CH3OH with relatively low current efficiencies.

A modified Jean Marie Lehn catalyst (2,2'-bipyridyl)Re$(CO)_3$Cl was also synthesized and polymerized on the electrodes. Such a catalytic electrode shows significant production of CO in acetonitrile with Faradic Efficiency up to 30%.

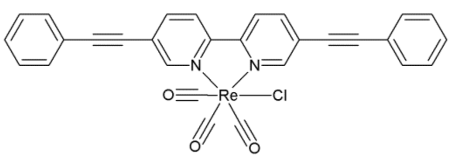

Fig. 3: Modified Jean Marie Lehn catalyst for polymerization on the electrode.

Our recent publications on this topic for further reading:

1.) E. Portenkirchner, J. Gasiorowski, K. Oppelt, S. Schlager, C. Schwarzinger, H. Neugebauer, G. Knoer, N. S. Sariciftci, ChemCatChem 5 (2013), 1790

2.) E. Portenkirchner, K. Oppelt, D. Egbe, G. Knoer, N. S. Sariciftci
Nanomaterials and Energy Vol 2, Issue NME3, (2013), 134

3.) E. Portenkirchner, D. Apaydin, G. Aufischer, M. Havlicek, M. White, M. C. Scharber, N. S. Sariciftci, ChemPhysChem 15 (2014), 3634

4.) E. Portenkirchner, C. Enengl, S. Enengl, G. Hinterberger, S. Schlager, D. Apaydin, H. Neugebauer, G. Knör, N. S. Sariciftci ChemElectroChem 1 (2014), 1543