

Interactive comment on “Ideas: Photoelectrochemical carbon removal as negative emission technology” by Matthias M. May and Kira Rehfeld

Matthias M. May and Kira Rehfeld

matthias.may@physik.hu-berlin.de

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We thank Prof. Parkinson for his valuable comments. In the following, we address them on a point-to-point basis.

Referee: 1. “I do find it unlikely that anyone who is investing substantial energy in a CO₂ reduction product, that also has fuel value, can be persuaded to sequester the product. Even the first reduced product, formate, that has the highest potential for efficiency is essentially a hydrogen carrier.”

Authors: This concern is also valid for other negative emission approaches such as

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biomass production. Therefore, the creation of incentives to actually sequester the products of negative emission technologies is certainly an issue that has to be addressed in future climate treaties. We will add a general statement to the manuscript.

Referee: 2. “On page 2 line 19 they suggest that the reduced products could be used as precursors to "organic construction materials". Given the scale of what would be needed it would be unlikely that such a huge market for such a material would exist. And if so it would have to be something much cheaper than could be justified from the cost of the electrons needed to reduce the CO₂. Large subsidies might be needed to make this possible.”

Authors: It is true that the market for organic construction materials or other plastics will probably be smaller than the volume of products generated by negative emission technologies in the anticipated scenarios, i.e. 10 Gt CO₂ per year by 2050. We see this rather as an added benefit since energy and money will have to be invested anyway for the achievement of a (sub) 2°C target limit for global warming with the aid of negative emissions. To what extent the further use of the carbon-rich products (such as for organic plastics) will make sense economically, will depend on the costs of sequestration as well as the future costs for the extraction of the remaining fossil oil resources.

Referee: 3. “I would like to see the authors include oxalate in their analysis since this requires only one electron per CO₂ and could be stored as solid oxalic acid dihydrate by concentrating the reduced brine or as precipitated calcium oxalate if a calcium source other than CaCO₃ or limestone could be used such as CaCl₂ from the ocean or other natural brines.”

Authors: We appreciate this suggestion. Oxalate is indeed a highly interesting product which we had not included. Oxalate production from CO₂ comes with an electrochemical load of 1.82 eV [e.g. Qiao et al, Chem. Soc. Rev., 2014, 43, 631] and one electron per CO₂ molecule. The overall resulting solar-to-carbon efficiency in our model (with its idealised catalysis), would be with system loss about 15%, which is significantly higher

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than formate (see Fig. 1, update to Fig. 1c,d in the manuscript). With respect to point 1, one could argue that oxalate is a lower-value molecule, which results in a higher incentive to actually sequester the product.

We will include the discussion above and the updated figure in the revised version of our manuscript.

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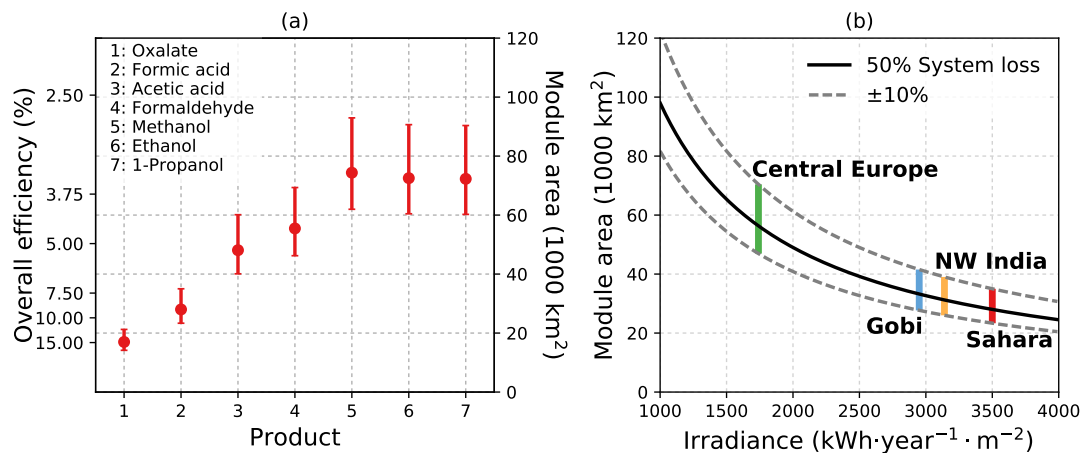


Fig. 1. Efficiency and module area for the -10 Gt CO₂/year scenario. (a) STC efficiency and module area required under Sahara irradiance at 50% system loss. (b) Module area for formic acid production.

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