In-situ Advanced Oxidation Processes For Novel Drinking Water Treatment Technology In Developing Countries

Ibrahim Prince Tholley and Chedly Tizaoui
Water and Resources Recovery Research Lab, Department of Chemical Engineering, Swansea University, Swansea, SA1 8EN, UK
Correspondence: 936416@swansea.ac.uk; c.tizaoui@swansea.ac.uk

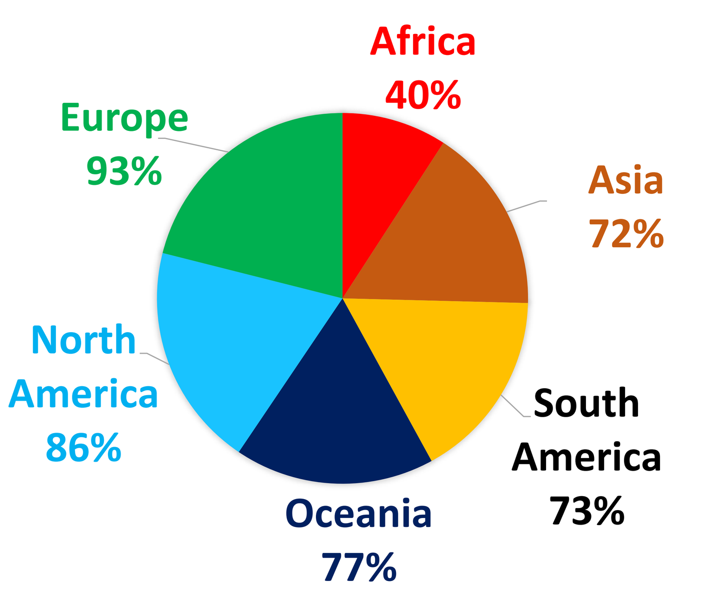
Swansea University
Prifysgol Abertawe

1. Background - The Big Issue!

Imagine you are living in a country like Chad, Central African Republic or Sierra Leone where you are 90% or more likely to ingest faecal or toxic chemicals from unsafe drinking water.

- 1 out of 3 people ≈ 2.2 billion worldwide lack safe water services [1], with developing sub-Saharan Africa worst affected [2].
- Only 6.2% of countries (15) globally have 100% access to safe drinking water, excluding the UK and other world powers [3].
- Clean and safe drinking water remains a significant global health and development issue [4].

AVERAGE % OF ACCESS TO CLEAN WATER



- Drinking water sources are contaminated with complex mixtures of particulate, chemical and microbial pollutants, like organics, heavy metals [5], pharmaceuticals, endocrine disruptors, pesticides, dyes, and industrial chemicals, that are often persistent, non-biodegradable, and cannot be effectively removed by conventional treatment methods, leading to widespread safety concerns [6].

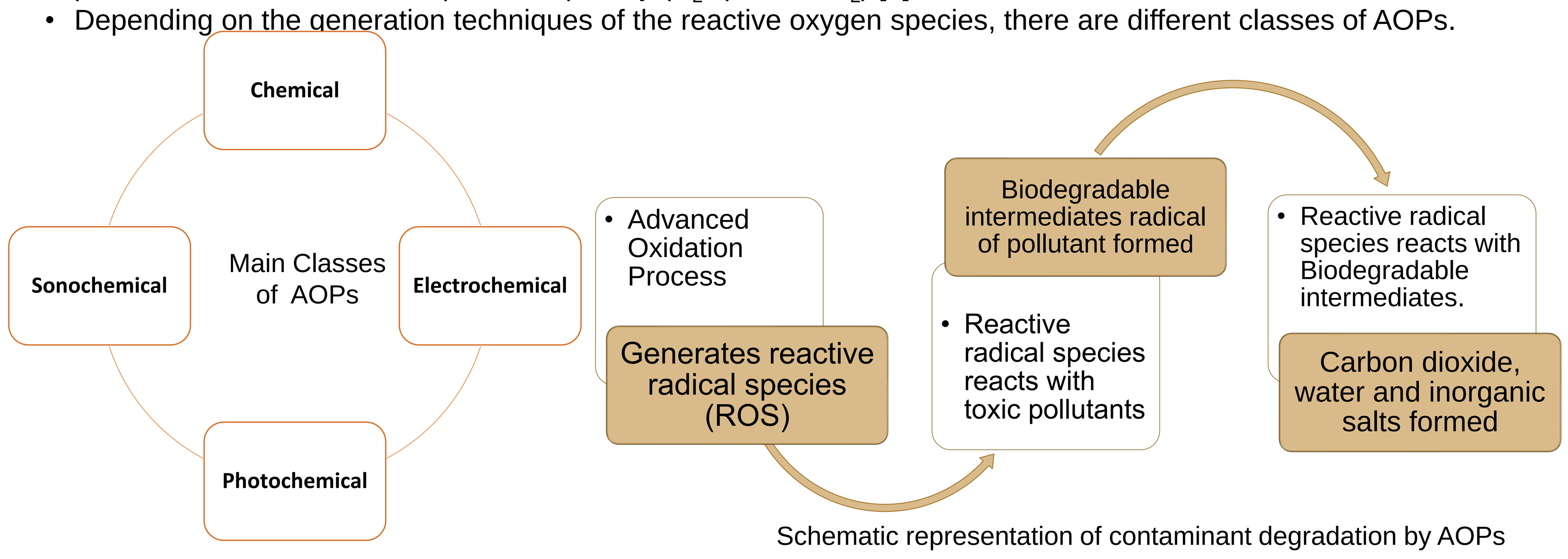
THE WAY TO GO!

This research will explore the design of a novel electrochemical advanced oxidation process-based electrochemical reactor integrated with microfiltration and solar energy for in-situ drinking water purification as a promising water treatment approach to improve access to high-quality drinking water.

6 CLEAN WATER AND SANITATION

2. The Theory

- Advanced oxidation processes (AOPs) are non-selective chemical treatment techniques often used to mineralise a broad spectrum of water contaminants that are otherwise resistant to conventional treatment techniques [7]. AOPs are also effective against pathogenic microorganisms such as *Bacillus, Mycobacterium* etc.
- AOPs traditionally rely on grid electricity for in situ generation of highly reactive oxygen species (ROS) such as hydroxyl (•OH), superoxide ($O_2^{\bullet-}$), ozone (O_3), and hydrogen peroxide (H_2O_2), to mineralise recalcitrant pollutants into harmless end-products (mainly H_2O, and CO_2) [8].
- Depending on the generation techniques of the reactive oxygen species, there are different classes of AOPs.



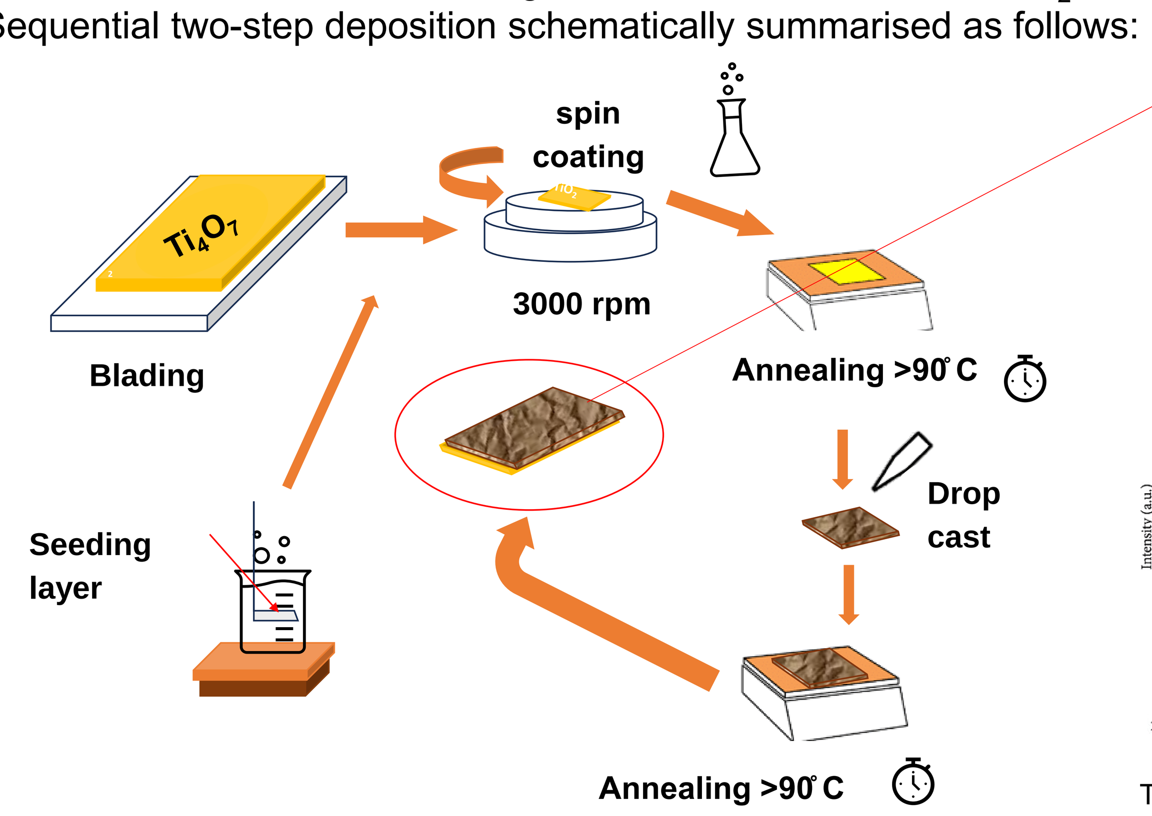
Schematic representation of contaminant degradation by AOPs

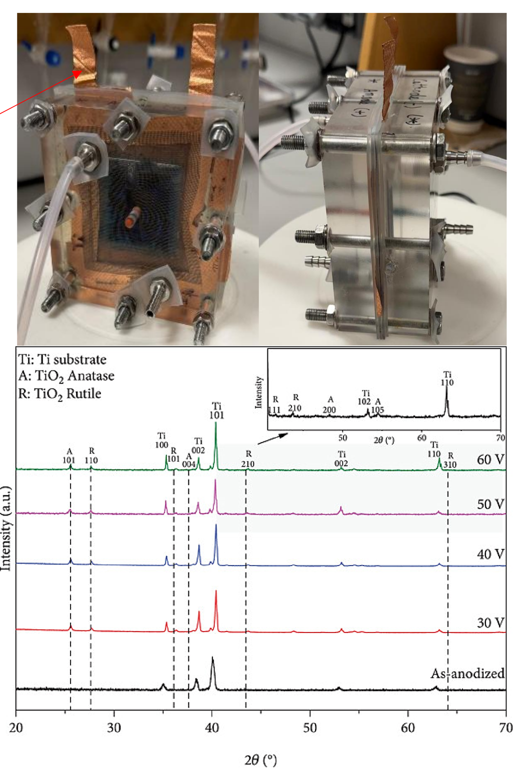
Advantages:
- High degradation rates, non-selectivity, and complete mineralisation of pollutants without any phase changes.
- No added chemical inputs
- No secondary waste concentration.

- Electrochemical Advanced Oxidation Processes (EAOPs) have become promising for the treatment of toxic recalcitrant and bio-refractory compounds and DBPs [9].
- Easy installation and operation, Cost effective and Environmentally friendly.

3. Fabrication & Characterisation

- Electrode material plays a key role in the oxidation efficiency of EAOPs.
- Novel electrode fabrication techniques and materials will be explored to develop highly efficient electrodes that will increase the generation of ROS and inhibit O_2 evolution.
- Sequential two-step deposition schematically summarised as follows:





Typical XRD spectra for anodised TiO_2 samples (Zakir, Idouhli et al. 2020)

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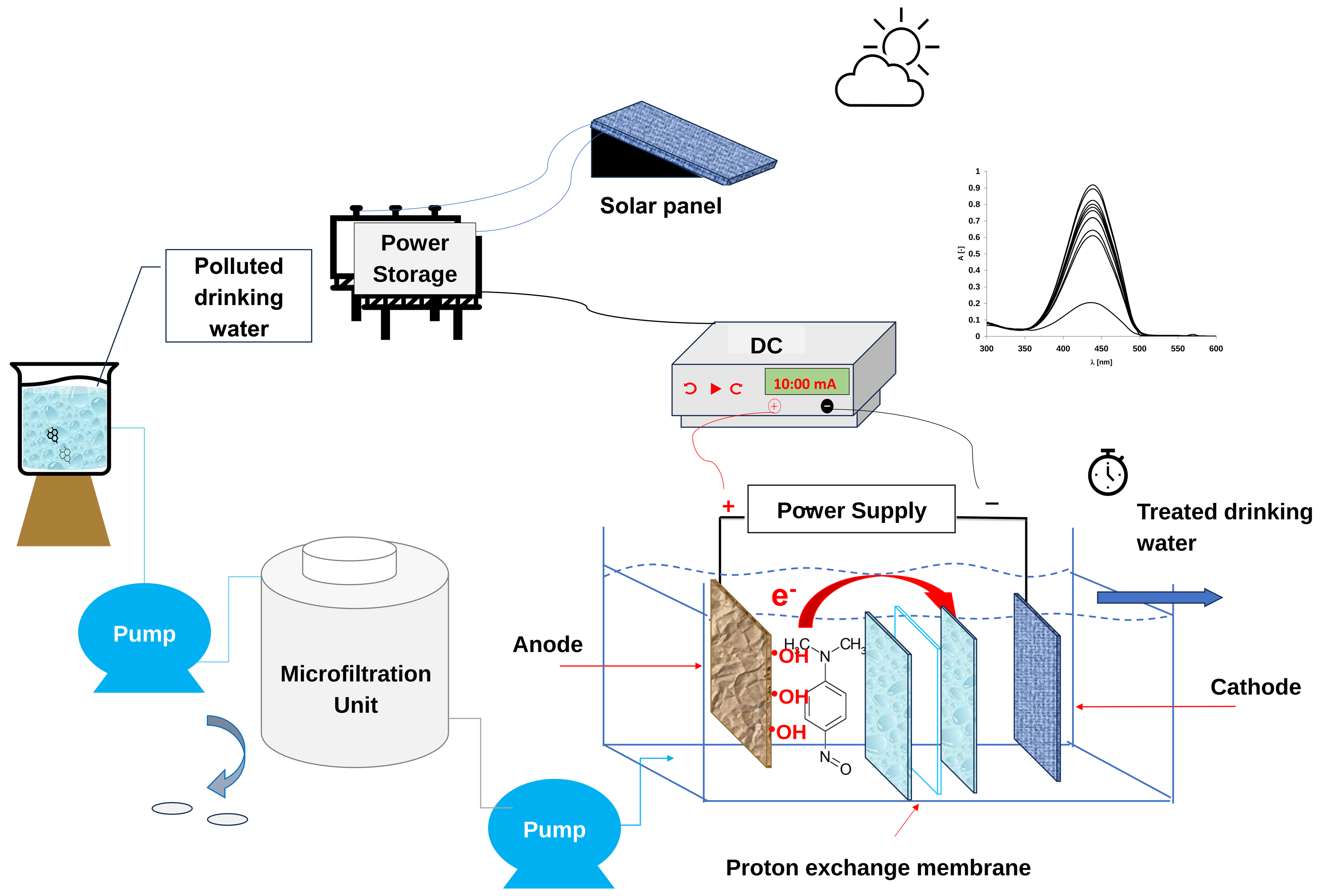
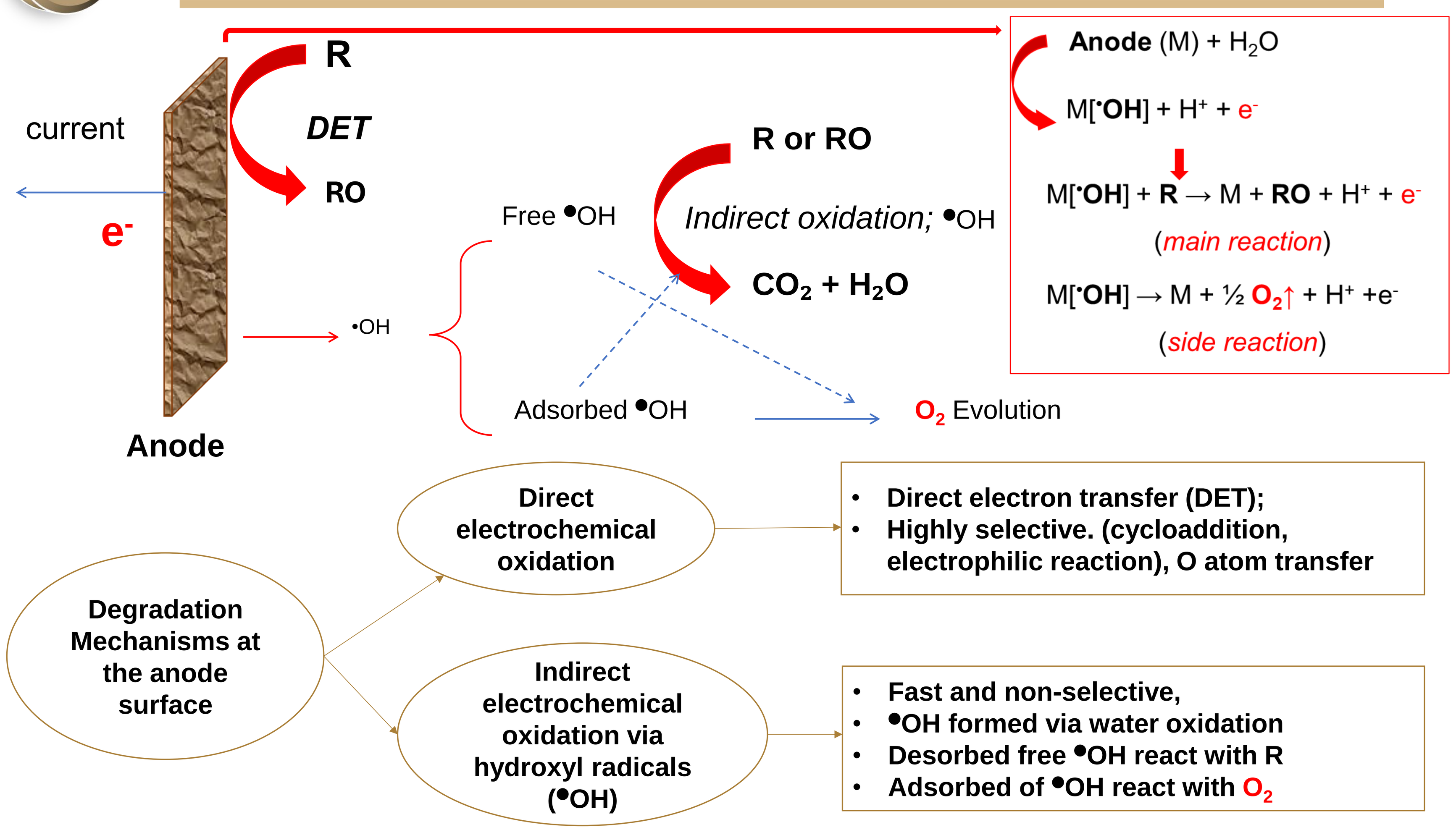
4. Proposed Hybrid Technology

- The synergy between solar-driven AOP and microfiltration can be exploited by designing reactor layouts that allow sequential treatment: first removing debris and colloids (microfiltration) followed by effective use of solar-induced radicals to attack dissolved organics



5. Application and Mechanism



- The combination of DET and indirect oxidation overcomes some of the limitations associated with other AOPs. The ability to oxidize compounds by both mechanisms provides an advantage when target compounds can compete for •OH
- Electrode material plays a key role in the oxidation efficiency.

6. Conclusion

- The use of renewable energy-powered AOPs remains unexplored and has seen limited application in sub-Saharan Africa, constituting a missed opportunity.
- Integration with AOP creates a "polishing" effect where microfiltration handles bulk particulates and AOP deals with dissolved and recalcitrant pollutants as well as water disinfection.

7. References

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