

Selective oxidation with air by cooperative cascade catalysis

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Selective oxidation of organic molecules is a **catalytic paradox**. Oxygen is freely available, but its high kinetic barrier means that once it is activated, reactivity is high and selectivity is low. There are three traditional solutions to this: (i) work at low conversion, keeping the selectivity high. This engineering solution is practical, but it means large recycle streams and low per-pass yields. (ii) use H_2O_2 , peracetic acid or *t*-BuOOH instead of oxygen. This also works, but it costs an extra reagent. (iii) Use platinum. Well, platinum can activate O_2 , but it's often too expensive for large-scale applications.

But there is a fourth way: some catalytic surfaces can donate an electron to the antibonding orbital in the oxygen molecule, creating a short-lived “peroxide-like” species. In the lecture, I will show how to make these materials and control their surface parameters.^[1–3] Then I will show how this active oxygen species can be generated and applied in the selective oxidation of alcohols and alkenes using **cooperative cascade catalysis**.^[4]

- [1] A simple synthesis of an N-Doped carbon ORR Catalyst: Hierarchical micro/meso/macro porosity and graphitic shells. D. Eisenberg, W. Stroek, N. J. Geels, C. S. Sandu, A. Heller, N. Yan and G. Rothenberg, *Chem. Eur. J.*, **2016**, 22, 501.
- [2] A rational synthesis of hierarchically porous, N-doped carbon from Mg-based MOFs: Understanding the link between nitrogen content and oxygen reduction electrocatalysis. D. Eisenberg, W. Stroek, N.J. Geels, S. Tanase, M. Ferbinteanu, S.J. Teat, P. Mettraux, N. Yan and G. Rothenberg, *Phys. Chem. Chem. Phys.*, **2016**, 18, 20778.
- [3] The evolution of hierarchical porosity in self-templated nitrogen-doped carbons and its effect on oxygen reduction electrocatalysis. D. Eisenberg, P. Prinsen, N.J. Geels, W. Stroek, N. Yan, B. Hua, J.-L. Luo and G. Rothenberg, *RSC Adv.*, **2016**, 6, 80398.
- [4] Cooperative catalysis for selective alcohol oxidation with molecular oxygen. T.K. Slot, D. Eisenberg, D. van Noordenne, P. Jungbacker and G. Rothenberg, *Chem. Eur. J.*, **2016**, 22, 12307.

Gadi Rothenberg received his BSc in Chemistry magna cum laude from the Hebrew University of Jerusalem in Israel in 1993, and his PhD in Applied Chemistry summa cum laude from the same university in 1999. He then worked as a Marie Curie Fellow at the University of York before moving to the University of Amsterdam in 2001. Since 2008 he is **Professor and Chair of Heterogeneous Catalysis & Sustainable Chemistry**. Rothenberg teaches courses on catalysis, thermodynamics and scientific writing. He has published two books and over 180 papers in peer-reviewed journals. His textbook “Catalysis: Concepts & Green Applications” is a Wiley-VCH bestseller. He has also invented **16 patents**, and co-founded **three companies**. His latest invention is a new catalyst for cleaning cyanide from wastewater, which is now running on an industrial pilot scale.

