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Neodymium-Doped Zinc Oxide Nanoparticles Catalytic Cathode for Enhanced Efficiency of Microbial Desalination Cells

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Abstract: The Microbial Desalination Cell is a novel method for desalinating water that also generates energy via substrate oxidation. The MDC comprises three chambers: the anode chamber, the desalination chamber, and the cathode chamber. The fundamental problem with the technology is that it generates very little power during the oxygen reduction reaction (ORR). One solution to this issue is to use a highly active cathode catalyst, which effectively increases the ORR rate. Neodymium-doped ZnO nanoparticles were produced and employed as a cathode catalyst in the three-chambered MDC1 to improve performance. $Zn_{1-x}Nd_xO$ nanocrystalline samples containing x = 0.0, 0.03, 0.6, and 0.10 were synthesized efficiently through the cost-efficient sol-gel method. Transmission electron microscopy (TEM) and X-ray diffraction techniques revealed the nanocrystalline nature and the phase purity of the $Zn_{1-x}Nd_xO$ samples. The structural properties of ZnO nanostructured materials were elucidated by Rietveld refinement of the XRD patterns, which showed displacement of Zn and O ions and revealed changes in the electron density around the Zn-O bond with Nd substitution. The local features of light emission from $Zn_{1-x}Nd_xO$ samples have been studied with photoluminescence. The UV and green-yellow emissions originate from the exciton transition and the transition between the Nd^{3+} deep level, oxygen vacancy and interstitial oxygen. The results were compared to MDC-2, which did not have a catalyst on the cathode. Both MDCs were tested using a saline water solution containing 15 g/L of NaCl to measure their desalination performance. The better reduction kinetics was confirmed by cyclic voltammetry of the MDC-1 cathode. MDC-1 had a higher desalination efficiency (77.02% ± 2.0%) due to the presence of an Nd-doped ZnO catalyst than MDC-2 (59.3% ± 8.3%). MDC-1's maximum power density of 3.65 W/m^3 was 2.78 times greater than MDC-2's (0.78 W/m^3). Furthermore, the coulombic efficiency of MDC-1 was found to be (8.8 ± 0.3%), which was much higher than that of MDC-2 (4.56 ± 0.2%). As a result, the Nd-doped ZnO-based catalyst developed in this study can potentially improve ORR in MDC cathodes, enabling them to generate more power.

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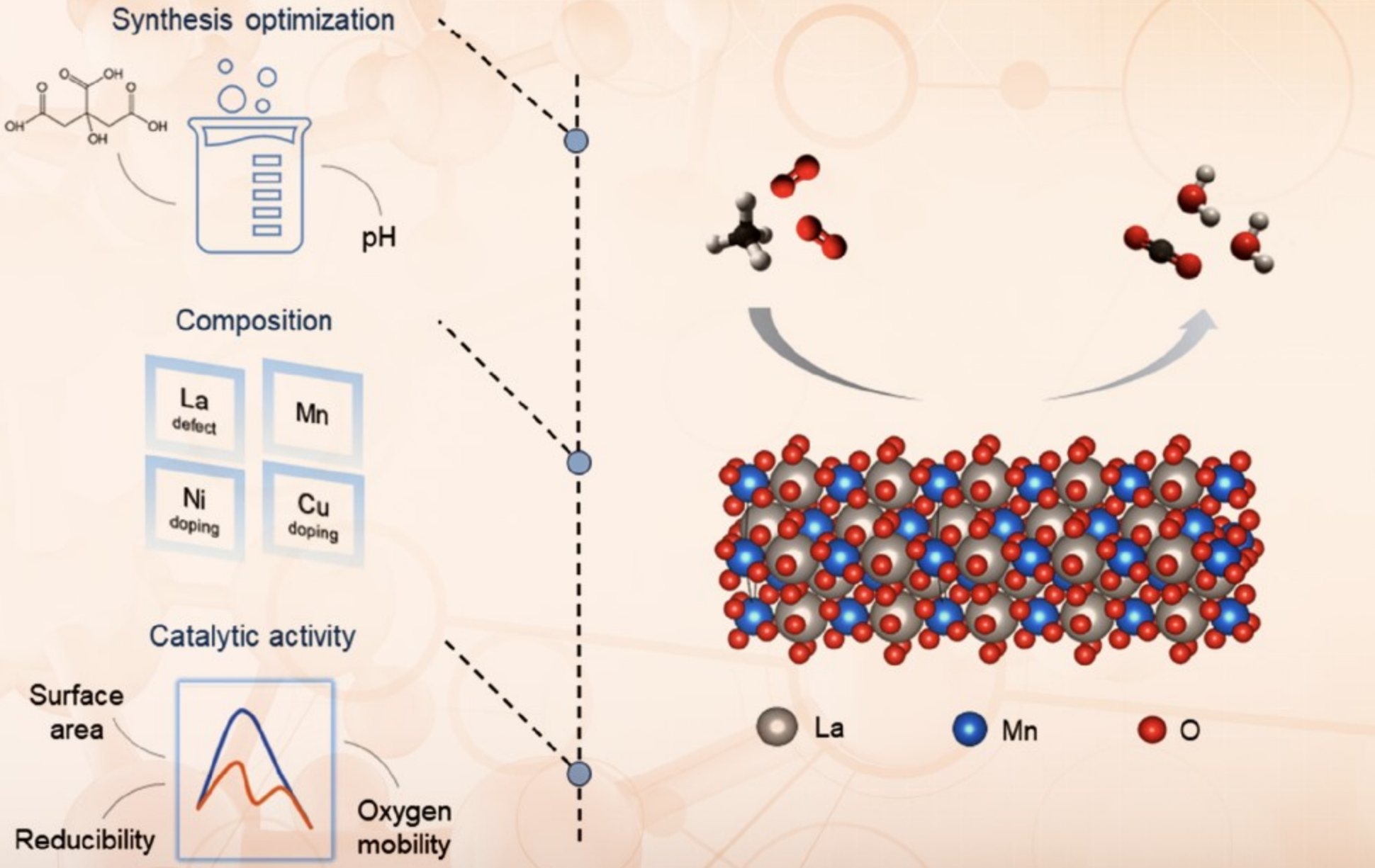

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