

ACTIVATION OF PEROXOMONOSULFATE ION BY BIOCHAR FOR THE DEGRADATION OF TRIMETHOPRIM IN AQUEOUS SYSTEMS

¹Dinesh Chandola, ¹Sinkovics Erik, ²Zsuzsanna László and ¹Tünde Alapi

¹*Department of Molecular and Analytical Chemistry, University of Szeged, H-6720 Szeged, Dóm tér 7, Hungary*

²*Department of Biosystem Engineering, Faculty of Engineering, University of Szeged, Moszkvai Blvd. 9., H-6725 Szeged, Hungary
e-mail: dinesh.chandola@chem.u-szeged.hu*

Water treatment processes have recently faced many challenges; one of these is the removal of trace pollutants from biologically treated waters in order to prevent their release into our environment. Advanced Oxidation Processes (AOPs) based on sulfate radical ($\text{SO}_4^{\cdot-}$) generation are efficient methods for water treatment that have gained attention in recent years. Highly reactive $\text{SO}_4^{\cdot-}$ can be generated in various ways; one of them is the application of biochar, as a sustainable and cost-effective carbon catalyst of persulfate activation.

In this study, the application of various biochars for the activation of peroxomonosulfate ion (PMS) and degradation of trimethoprim antibiotic, as an emerging pollutant of surface waters was examined. Biochars were prepared from different raw materials, such as grass pellets (GP-BC), corncobs (CC-BC), and poplar wood (PW-BC). The effect of pyrolysis temperature (500, 600, and 700 °C) and ball milling on the adsorption properties and activity of biochars was investigated. In catalytic runs, PMS concentration (up to 2.0 mM) and BC dose (up to 3000 mg dm⁻³) were changed. The contribution of various reactive species was also investigated.

During preliminary experiments, the BCs were used without ball milling, and the dose of BC and PMS was changed. 3000 mg dm⁻³ BC and 2.0 mM PMS were found to be optimal in terms of trimethoprim degradation. The activity depended on the raw material, and 71% (PW-BC), 78% (CC-BC), and 93% (GP-BC) trimethoprim elimination was reached after 120 minutes of treatment. Ball milling highly enhanced the surface area and adsorption capacity, and, consequently, the activity of BCs. In the case of ball-milled GP-BC, a dose of 500 mg dm⁻³ was sufficient to degrade 65% and 88% of the TMP with a 0.1 mM and 0.2 mM PMS dose, respectively, in 60 min. reaction time. However, with a PMS dose of 1.0 mM, trimethoprim completely degraded within 2 minutes. The GP-BC was found to be the most efficient for PMS activation, thus, the effect of pyrolysis temperature was investigated in this case. Even though the increase in pyrolysis temperature (500→700 °C) results in decreased adsorption capacity, the reactivity of BC prepared under 700 °C was the best in terms of PMS activation and trimethoprim degradation. The contribution of various reactive species, such as $\cdot\text{OH}$, $\text{SO}_4^{\cdot-}$, and singlet oxygen ($^1\text{O}_2$), was investigated by the effect of radical scavengers, and singlet oxygen ($^1\text{O}_2$) was found to be mainly responsible for trimethoprim degradation. The efficiency of the BC/PMS process was compared to BC/H₂O₂ process, as an alternative method, and BC/PMS was found to be superior. For the BC/H₂O₂ process, less than 20% of trimethoprim could be transformed after 60 min treatment, while using the BC/PMS process, 90% transformation efficiency was reached using the same experimental conditions.

Based on our results, the prepared BCs are suitable for PMS activation and, consequently, for trimethoprim degradation. The activity of BC depends on the quality of the starting raw material and the pyrolysis temperature and can be significantly increased by ball-milling due to the increased specific surface area. However, the formed $^1\text{O}_2$ is a selective reaction partner, which may limit the applicability of the method in the case of other organic removal.