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# Removal of metoprolol from water by sepiolite-supported nanoscale zero-valent iron

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## ABSTRACT

The presence of β-blockers (i.e. metoprolol (MPL)) as an emerging contaminant in aquatic environments has become a subject of concern because of their high solubility in water, consumption, and persistence. In this study, metoprolol was removed from water with sepiolite-supported nanoscale zero-valent iron (SPT-nZVI) to prevent agglomeration and provide a large reactive area. The SPT-nZVI was synthesized using the sodium borohydride reduction method and characterized by various techniques including Fourier-Transform infrared spectroscopy (FTIR), x-ray diffraction spectrometry (XRD), transmission electron microscope (TEM), scanning electron microscopy (SEM), and energy dispersive x-ray spectroscopy (EDAX). The selected parameters of solution pH, contact time, $H_2O_2$ concentration, initial MPL concentration, and dosage of nanoparticles were investigated and optimized. The results indicated that the maximum MPL removal rates in the absence and presence of water anions and cations were 67.24% ± 0.95 and 55.16 % ± 1.26, respectively, obtained under optimal conditions including an MPL concentration of 3 mg/L, 10 mM $H_2O_2$, SPT-nZVI dosage of 0.5 g/L, solution pH of 3, and contact time of 60 min. Kinetics study indicated that the removal of metoprolol was best fitted with the pseudo-second order model ($R^2$ = 0.9907). Hydroxyl radical production was successfully verified through the scavenging effect of methanol.

**Keywords**: Metoprolol; Sepiolite; Nanoscale zero- valent iron; Emerging contaminants; β-blocker

## 1. Introduction

Recently, a broad range of pharmaceuticals and personal care products (PPCPs) which are called emerging contaminants (ECs) in aquatic environments have attracted the attention of scientists [1, 2]. Chronic exposure to these contaminants, even at low concentrations, can have adverse effects on human health and aquatic organisms [3]. Various studies have shown that these pollutants can be found at levels above 10 ng/L in wastewater treatment plants ($WWTP_s$) [3], 1 ng/L in hospital wastewater (HWW) [4], and 0.008 ng/L in groundwater, surface water, and drinking water [3].

Pharmaceutical compounds such as antibiotics, antidepressants, anti-inflammatories, analgesics, and β-blockers have been reported to exist in treated effluents, which confirms the ineffectiveness of treatment methods [3].

Among these compounds, β-blockers (Beta-adrenergic receptor antagonist drugs) are widely used not only in hospitals, but also domestically [5]. β-blockers are prescribed for the treatment of cardiovascular diseases as well as disorders such as hypertension, angina, and cardiac arrhythmias [6-9]. Propranolol, atenolol, and metoprolol are included in this category [10, 11]. These drugs are highly polarized and soluble compounds in water and are among the highest selling drugs [10]. Of these drugs, metoprolol (MPL) has been detected in

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