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Degradation of veterinary antibiotics by dielectric barrier discharge plasma

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HIGHLIGHTS

- The plasma method is very energy-efficient for degrading antibiotics.
- The degradation followed exponential decay with respect to the delivered energy.
- Each antibiotic substance shows a different degradability in the plasma reactor.

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ABSTRACT

This work investigated the degradation of antibiotics in synthetically prepared wastewater by using dielectric barrier discharge (DBD) plasma. The veterinary antibiotics investigated include lincomycin, ciprofloxacin, enrofloxacin, chlortetracycline, oxytetracycline, sulfathiazole, sulfamethoxazole, sulfamethazine and trimethoprim. The effect of discharge power, initial concentration, working gas type (air or O_2) and working gas flow rate on the degradation was examined and discussed. The experimental results indicated that the antibiotics were easily degraded by the DBD plasma and the degradation rates were mainly governed by the amount of the delivered energy. The degradation of the antibiotics followed an exponential decay with respect to the delivered energy. Each antibiotic substance was found to show a different degradability. On the basis of an initial concentration of 5 mg L^{-1}, the energy requirements for 60% degradation efficiency were in the range of 0.26–1.49 kJ mg^{-1}, depending on the type of antibiotic substance, while those for 90% degradation efficiency ranged from 0.39 to 2.06 kJ mg^{-1}. The DBD process proposed in this work may be a promising method for effectively degrading veterinary antibiotics.

1. Introduction

Veterinary antibiotics are powerful drugs that prevent and fight bacterial infectious diseases of animals. Since prevention of disease transmission and enhancement of growth and feed efficiency are critical in modern animal husbandry, there has been widespread incorporation of antibiotics into feeds for livestock in many countries [1]. Even though estimates from different sources are not directly comparable, it is certain that there is considerable use of antibiotics in livestock farming. Releases of veterinary medicines to the environment occur both directly, for example through the treatment of animals on pasture, and indirectly, via the application of animal manure containing excreted products to land and once released to land, the veterinary medicines may leach to groundwater or be transported to surface waters in drainage waters and overland flow [2]. Such veterinary antibiotics may pose a risk to the environment as a new class of contaminants, and recently the potential hazard of residual antibiotics to the ecological system has been the subject of intense debate and research. In general, antibiotics have low biodegradability because they are biocidal substances. To arrest potential threat of antibiotics, misuse and abuse should be avoided, and in the long run, appropriate processes to effectively degrade the antibiotics need to be developed.

The degradation of antibiotics cannot be accomplished in the natural environment or biological treatment plants [3], and thus it is clear that chemical oxidation methods or advanced oxidation processes (AOPs) such as ozonation, photolysis, radiation and catalysis are necessary for the degradation of these pollutants; yet, there have so far been only a few studies reported in the literature. Bhakta and Munekage [4] investigated the degradation capacity of widely used trimethoprim and sulfamethoxazole antibiotics by employing ultraviolet (UV) light and TiO_2 in water phase, which revealed that the synergistic photocatalytic effects of the TiO_2 with UV leads to a rapid and higher degree of degradation of the antibiotics, compared to that of only UV photolysis.

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