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Review

Volatile Methyl Siloxanes as Potential Hazardous Air Pollutants

Kazimierz Gaj*, Anna Pakuluk

Faculty of Environmental Engineering, Wroclaw University of Technology,
Wybrzeże Wyspiańskiego 27, 50-370 Wroclaw, Poland

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Abstract

Due to the more and more common use of siloxanes in consumer products and various industries, there has been an increase of their concentration in biogases produced from sewage sludge and municipal waste and, consequently, in the soil, water, and air. This paper presents sources and mechanisms of siloxane migration to the environment, characterizes types and products of their transformations in the atmospheric air and during the combustion of biogas, assesses hazards posed to the atmospheric air, and presents the results of siloxane concentration measurements in biogases and the atmospheric air. It draws attention to the new problems that have emerged in toxicology and atmosphere protection, outlines directions for necessary research, proposes ways to reduce emissions of volatile methyl siloxanes (VMS), and suggests the introduction of relevant legislation.

Keywords: cosmetic products, waste, biogas, silicone compounds, toxicity

Introduction

Siloxanes are substrates of silicone polymers commonly used in many industries and household products. They are extensively used in cosmetic products as an ingredient of shampoos, deodorants, aerosols, and various types of treatments and colorings. They are also applied for the production of lubricants, adhesives, paints and solvents, foams (e.g. polyurethane), detergents, fabric softeners and protectors, seals, and elastomers. In medicine they have been used, e.g., in manufacturing of prostheses, implants, catheters, and blood transport equipment. They are increasingly replacing chlorofluorocarbons which, as they deplete the ozone layer and intensify the greenhouse effect, are gradually phased out. Due to the rising industrial consumption of silicones, they were included by the OECD in the list of high production volume chemicals [1]. In 2006 the European Commission issued Decision No. 2006/257/EC, establishing an inventory and a common nomenclature of ingredients employed in cosmetic products. This list includes approximately 200 compounds based on siloxanes. The above-mentioned waste products get to WWTPs and landfills, where VMS are released into the biogas produced there and into the air. Due to biogas combustion, they are partially oxidized to silica and silicates, thus blocking energetic devices with difficult-to-remove deposits and polluting the air with toxic microcrystalline silica.

In chemical nomenclature, siloxanes are non-organic silicon compounds composed of alternating Si and O atoms, wherein Si atoms are linked with hydrocarbon functional groups, such as methyl, ethyl, phenyl, and vinyl groups, or with hydrogen atoms. The silicon and oxygen atoms may be linked into linear or cyclic structures (Fig. 1). Because of possible combinations of side and end-groups, the industry uses hundreds of their various congeners. Due to high volatility, particularly important from the air protection perspective are VMS containing from 2

*e-mail: kazimierz.gaj@pwr.edu.pl