

Biological treatment of industrial wastewater containing formaldehyde and formic acid

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Abstract

The biological treatment of wastewater from an aminoplastic resin-producing industry was studied in a pre-denitrification system. This study reports results on the removal of organic matter and nitrogen compounds from wastewater which contained high levels of formaldehyde and formic acid. The formaldehyde concentration in the feed varied between 2 087.0 and 2 200.0 mg/l, the mean removal being 99.9%. The mean efficiency of formic acid removal was 99.7%, and its concentration in the feed ranged between 1 384.6 and 1 513.9 mg/l. The total organic carbon (TOC) values in the feed varied from 1 423.0 to 1 599.5 mg/l, corresponding to an organic loading rate of about 0.20 kg TOC/m³-d. High TOC removal was achieved, around 92.0%. With regard to nitrogen compounds, the total Kjeldahl nitrogen (TKN) concentration in the feed ranged between 467.8 and 492.3 mg/l. The applied nitrogen loading rate was around 0.06 kg TKN/m³-d, and the mean percentage of TKN removal was 76.7%.

Keywords: formaldehyde, formic acid, industrial wastewater, nitrogen removal, organic matter removal

Introduction

Wastewaters from aminoplastic resin-producing industries are characterised by high levels of organic matter and nitrogen compounds. In general, the organic matter is mainly present as formaldehyde and the nitrogen compounds as urea. Consequently, the biological treatment of these wastewaters requires a combined process of carbon and nitrogen removal. This biological treatment could be carried out in a pre-denitrification system, which is usually used to treat wastewaters with a high content of organic matter that can be used as carbon source for denitrification. The pre-denitrification system avoids or decreases the need for adding an external carbon source, which is interesting from an environmental and economic point of view. Organic matter removal, hydrolysis of nitrogen compounds and denitrification of nitrate recirculated from the aerobic unit would take place in the anoxic reactor. Nitrification of ammonium provided by the anoxic unit and biodegradation of the organic matter that would not have been removed in the anoxic reactor would take place in the aerobic reactor.

Cheng et al. (1996) studied the treatment of wastewaters from a resin-producing industry using a pre-denitrification system (anoxic-aerobic-aerobic) at laboratory scale. They achieved removal efficiencies of COD and TKN around, respectively, 95.3 and 83.8%; at organic loading rates of between 0.27 and 0.72 kg COD/m³-d and nitrogen loading rates of between 0.04 and 0.12 kg TKN/m³-d. Garrido et al. (2000) also studied the treatment of wastewaters from a resin-producing industry using a pre-denitrification system (anoxic-aerobic) at laboratory scale. They achieved COD removal efficiencies between 70 and 85%, at organic loading rates of between 0.7 and 1.9 kg COD/m³-d.

The purpose of this research was to study the biological treatment of wastewater from an aminoplastic resin-producing industry in a pre-denitrification system. The removal of organic matter and nitrogen compounds was analysed in a wastewater with high formaldehyde and formic acid concentrations.

Material and methods

Analytical methods

Formaldehyde was analysed spectrophotometrically according to the Hantzsch reaction (Nash, 1953), using a Perkin Elmer Lambda 11 UV/Vis spectrophotometer. Formic acid and phenol were determined using a Hewlett Packard 1100 liquid chromatograph equipped with a C-18 ODS column (25 cm x 4 mm ID) and a UV diode-array detector. The mobile phases were methanol: water (60:40) and acetonitrile: phosphoric acid (80:20), respectively. Detection was performed at 210 nm for formic acid and 280 nm for phenol. Methanol was measured using a Hewlett Packard 5890-II gas chromatograph equipped with a Nukol column (30 m x 0.25 mm ID) and a flame ionisation detector. Nitrogen (1.5 ml/min) was utilised as carrier gas. Injector and detector temperatures were 250 and 270°C, respectively. TOC was determined according to *Standard Methods* (1998), using a TOC-5050A Shimadzu.

Nitrite and nitrate were analysed by capillary electrophoresis using a Hewlett Packard ^{3D}CE system with a micro-capillary tube of fused silica (40 cm x 50 µm ID). UV detection was undertaken at a wavelength of 214 nm and 450 nm as reference. The biogas composition (N₂, CH₄, CO₂ and N₂O) was analysed on a Hewlett Packard 5890-II gas chromatograph equipped with a Porapak Q W80/100 column (2 m x 3.2 mm ID) and a thermal conductivity detector. Helium (15 ml/min) was utilised as carrier gas. Injector, oven and detector temperatures were 90, 25 and 100°C, respectively. Ammonium, pH, TKN and VSS were evaluated according to *Standard Methods* (1998).

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