

# The Effect of Certain Anionic Detergents on the Process of Desulfurication

K. Szymańska, F. Domka, E. Wawrzyniak

Department of Kinetics and Catalysis, Faculty of Chemistry, Adam Mickiewicz University,  
Grunwaldzka 6, 60-780 Poznan, Poland

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## Abstract

The effect of sodium dodecylsulphate (SDS), sodium alkylbenzenesulphonate (ABSNa) and sulphosuccinates IOP5 and N5, present in different concentrations, on the kinetics of desulfurication conducted with the use of *Desulfotomaculum ruminis* bacteria was analysed. As follows from the determined activity of the microorganisms, the presence of SDS and ABSNa inhibits the process of desulfurication. The toxic concentrations of these compounds were established as 60 mg/dm<sup>3</sup> for SDS and 450 mg/dm<sup>3</sup> for ABSNa. The presence of sulphosuccinates IOP5 and N5, even at the concentration of 20g/dm<sup>3</sup>, does not affect the activity of *Desulfotomaculum ruminis* bacteria but these compounds cannot be used as a source of carbon by the microorganisms.

**Keywords:** bacteria, *Desulfotomaculum ruminis*, desulfurication, toxicity, surfactants, sodium dodecylsulphate (SDS), sodium alkylbenzenesulphonate (ABSNa), sulphosuccinate (IOP5, N5)

## Introduction

Detergents make a group of synthetic compounds belonging to the so-called surfactants, the substances not only replacing soap but many other applications. They are characterised by very good washing, emulsifying, wetting, dispersing, foam producing and sometimes bacteriostatic properties.

For example sulfonians - propylene derivatives, are as well soluble in water as soap and act in the form of anions, making a group of anion detergents. They are the main components of washing powders and fluids, agents for washing dishes or kitchen and toilet utilities. The recent increase in their use can lead, however, to harmful effects. As follows from literature reports [1] the concentration of anion surfactants in municipal wastes reaches up to 20 mg/dm<sup>3</sup>, and in industrial waste from plants using or producing surfactants - even up to a few g/dm<sup>3</sup>. In surface waters the concentration of surfactants usually

does not exceed 0.1 mg/dm<sup>3</sup>, and according to Polish standards the admissible concentration of surfactants in drinking water should not exceed 0.2 mg/dm<sup>3</sup> [2]. Depending on the degree of branching of the lipophilic substituent they are more or less resistant to biodegradation [3].

Solutions of detergents finally reaching natural waters pose a threat to them not only because of the foam remaining on the surface and hindering the oxygen penetration but also because of their toxicity [1, 4, 5]. Their presence inhibits development of living organisms so also self-purification of water reservoirs, while foam production hinders the work of turbines and aerating devices in waste purification plants. Moreover, thanks to the emulsifying properties, the surfactants facilitate the penetration of many toxic substances such as pesticides or hydrocarbons into water environment, and in emulated form these toxic substances are more accessible to living organisms. Apart from the above effects, high concentra-

tions of detergents often produces allergic reactions, can damage cytoplasmic membrane playing a fundamental role for bacteria cells, or even totally inhibit development of living organisms. To preserve ecological balance these substances must be effectively neutralised and the first step towards this aim is assessment of their toxicity in water environment and susceptibility to biodegradation. The study reported in this work was undertaken to assess the degree of biodegradation of the most popular anionic surfactants on the basis of kinetics of the process of growth of *Desulfotomaculum ruminis* bacteria. These bacteria reduce sulphates and belong to the group of microorganisms taking part in self-purification of water reservoirs [6]. Moreover, toxic concentrations of surfactants were determined and they were tested as a possible source of carbon for *Desulfotomaculum ruminis* bacteria.

## Materials and Methods

The bacteria reducing sulphates were isolated and identified as *Desulfotomaculum ruminis* by the method described earlier [7].

Kinetic studies were conducted at 37°C, in anaerobic conditions (helium), at pH = 6.8-7.2, in sealed glass reactors containing 50 cm<sup>3</sup> of the modified Starkey' medium composed of [g/dm<sup>3</sup>]: MgSO<sub>4</sub> · H<sub>2</sub>O = 2.00, Na<sub>2</sub>SO<sub>4</sub> = 2.66, NH<sub>4</sub>Cl = 1.00, K<sub>2</sub>HPO<sub>4</sub> = 5.00, CaCl<sub>2</sub> = 0.13, Mohr salt = 0.006, sodium lactate = 25 and microelements [8]. Appropriate amounts of the surfactants studied were added to the medium, which was deoxidised and inoculated with a 4% vol of inoculum collected in the phase of the logarithmic growth of the bacteria (after 24h). The reaction rate was measured as the degree of reduction of sulphates to sulphides determined at certain time intervals.

Sulphosuccinates IOP5 and N5 have been also tested as a possible source of carbon for growing bacteria. To do that different amounts (1, 5, 10, 15, 20 g/dm<sup>3</sup>) of the surfactants tested were introduced into the medium instead of sodium lactate and then the medium was inoculated.

The instruments and media were sterilised for 20 min. at 120°C. Analogous experiments were also conducted in the same conditions for the reference samples without the surfactants studied. Results are averages of at least 3 measurements.

**Methods of analysis.** Changes in the concentration of sulphades were determined by the iodometric method after precipitation of CdS [9].

## Results and Discussion

As follows from the data presented in Fig. 1, introduction of SDS in a concentration of 0.008 g/dm<sup>3</sup> into the medium decreases the degree of sulphates reduction by about 15% after 50 hours. With increasing concentration of this surfactant to the level 0.035 g/dm<sup>3</sup> a further 15% decrease of the degree of conversion is observed. Total inhibition of desulfurication reaction occurs after introduction of 0.06 g/dm<sup>3</sup> of SDS in the medium, so this concentration of SDS was assumed as toxic.

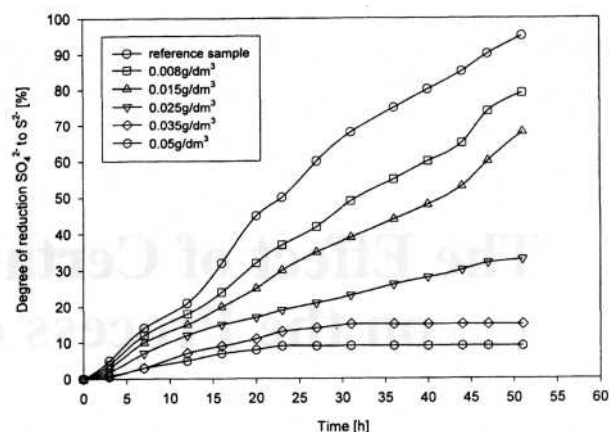


Fig. 1. Degree of desulfurication [%] taking place with the use of *Desulfotomaculum ruminis* bacteria in the media with different concentrations of sodium dodecylsulfate (SDS) (pH = 6.8 - 7.2, C/S = 9.3, temp. 37°C).

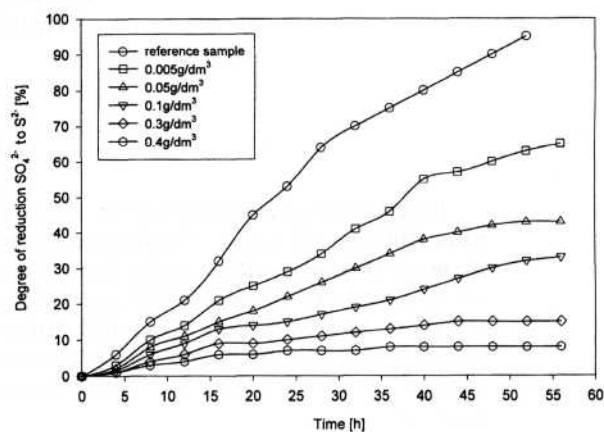


Fig. 2. Degree of desulfurication [%] taking place with the use of *Desulfotomaculum ruminis* bacteria in the media with different concentrations of sodium alkylbenzenesulphonate (ABSNa) (pH = 6.8 - 7.2, C/S = 9.3, temp. 37°C).

A similar effect on desulfurication is observed after introduction of ABSNa (Fig. 2). Its presence at a concentration of 0.005 g/dm<sup>3</sup>, after 55 hours decreases the final degree of conversion from 95 to 65%. With a further increase in the ABSNa concentration the degree of conversion decreases and e.g. for 0.1 g/dm<sup>3</sup> ABSNa it occurs only in 33%. As follows from the toxicity test the ABSNa at a concentration of 0.45 g/dm<sup>3</sup> totally inhibits the growth of *Desulfotomaculum ruminis* bacteria.

The influence of sulphosuccinate IOP5 on the process of desulfurication was studied in the range of its concentrations from 2 to 20 g/dm<sup>3</sup> (Fig. 3). In this concentration range no significant effect of this surfactant on the course of desulfurication has been observed. The only change was a small increase in the time of the reaction. The degree of conversion after 64 hours remains at the level of 80%, a level admissible by Polish standards [10].

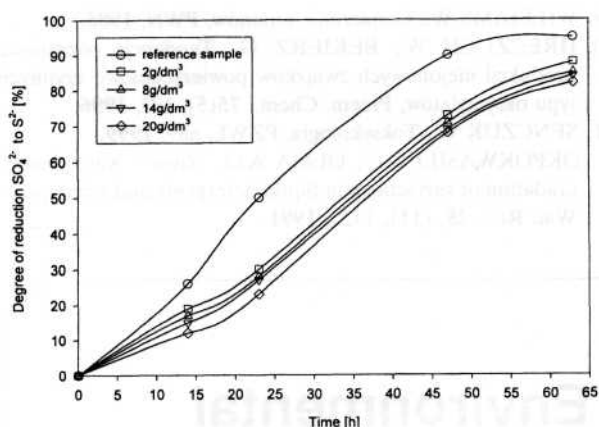


Fig. 3. Degree of desulfurication [%] taking place with the use of *Desulfotomaculum ruminis* bacteria in the media with different concentrations of sulphosuccinate (IOP5) (pH = 6.8 - 7.2, C/S = 9.3, temp. 37°C).

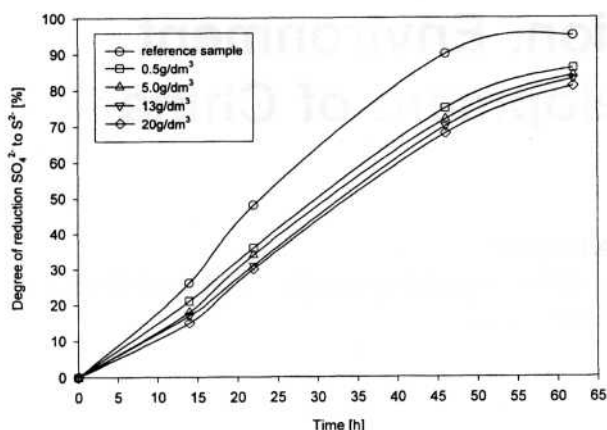


Fig. 4. Degree of desulfurication [%] taking place with the use of *Desulfotomaculum ruminis* bacteria in the media with different concentrations of sulphosuccinate (N5) (pH = 6.8 - 7.2, C/S = 9.3, temp. 37°C).

Similarly, the addition of sulphosuccinate N5, even at a concentration of 20 g/dm<sup>3</sup>, also does not cause significant changes in the activity of the bacteria so also in the degree of conversion (Fig. 4).

At the next step the sulphosuccinates studied were tested as a possible source of carbon for the bacteria *Desulfotomaculum ruminis*. Unfortunately, even after seven days of adaptation to the medium in which sodium lactate was replaced by the sulphosuccinates, no activity of the bacteria was observed. Therefore, the sulphosuccinates lose the properties characteristic of a surfactant. It cannot be excluded that the bacteria feed on the products of biodegradation available for usual metabolic pathways. The procedure applied does not explain this specific behaviour. However, as follows from some earlier studies, certain compounds undergo degradation by microorganisms only when they occur together with some other substances [11]. This type of degradation which alone cannot support the growth of bacteria but takes place in the

presence of another degraded substance, treated as co-metabolism plays an important role in the destruction of organic pollutants in the environment.

The surfactants sodium dodecylsulphate and sodium alkylbenzenesulphonate have an evident inhibiting effect on desulfurication reaction. It can be explained by the affinity of the hydrophobic groups of these surfactants to the bacteria membranes. Thanks to their properties the surfactants present at certain concentrations can weaken bonds between lipids and proteins and thus cause partial or total destruction of the cytoplasmic membrane, which would inhibit the activity of *Desulfotomaculum ruminis* bacteria and decrease the yield of desulfurication.

The results obtained prove that the biodegradation susceptibility of the surfactants tested decreases in the sequence: sodium dodecylsulphate (SDS) > sodium alkylbenzenesulfonate (ABSNa) > sulphosuccinate (IOP5) = sulphosuccinate (N-5). This result means that certain surfactants can be susceptible to the attack of the sulphate reducing bacteria, while certain others can inhibit the bacteria activity.

The results obtained can be of interest to those involved in protection of the environment, mainly water reservoirs, against pollution with surfactants. Apart from the information on the biodegradation rate in certain degree of pollution with surfactants, their toxic concentrations have been determined. From among the surfactants studied, the most pronounced influence on the growth of *Desulfotomaculum ruminis* bacteria exerted the presence of sodium dodecylsulphate (SDS) and sodium alkylbenzenesulphonate (ABSNa). These two compounds in concentrations higher than the accessible standard [10] are resistant to the attack of the bacteria *Desulfotomaculum ruminis*, while the presence of the sulphosuccinates tested does not have a significant effect on the bacteria.

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