Available online at www.sciencedirect.com
SCIENCE DIRECT®
Corrosion Science 47 (2005) 257–271
CORROSION SCIENCE
www.elsevier.com/locate/corsci

Bacterial degradation of naphtha and its influence on corrosion

A. Rajasekar, S. Maruthamuthu *, N. Muthukumar, S. Mohanan, P. Subramanian, N. Palaniswamy

Corrosion Science and Engineering Division, Central Electrochemical Research Institute, Karaikudi 630006, India

Received 1 December 2003; accepted 14 May 2004
Available online 15 July 2004

Abstract

The degradation problem of naphtha arises since hydrocarbon acts as an excellent food source for a wide variety of microorganisms. Microbial activity leads to unacceptable level of turbidity, corrosion of pipeline and souring of stored product. In the present study, biodegradation of naphtha in the storage tank and its influence on corrosion was studied. The corrosion studies were carried out by gravimetric method. Uniform corrosion was observed from the weight loss coupons in naphtha (0.024 mm/yr) whereas in presence of naphtha with water, blisters (1.2052 mm/yr) were noticed. The naphtha degradation by microbes was characterized by Fourier transform infrared spectroscopy (FTIR) and nuclear magnetic resonance spectroscopy (NMR). IR study reveals the formation of primary alcohol during degradation process. It was found that microbes degrade $(-CH_2-CH_2-)_n$ to $R-CH_3$. Iron bacteria, manganese oxidizing bacteria, acid producers, and heterotrophic bacteria were enumerated and identified in the pipeline. SRB could not be noticed. Since water stratifies in the pipeline, the naphtha-degraded product may adsorb on pipeline, which would enhance the rate of microbial corrosion. On the basis of degradation and corrosion data, a hypothesis for microbial corrosion has been proposed.

Keywords: Mild steel; Microbiological corrosion; Naphtha degradation; IR spectroscopy; NMR spectroscopy; Weight loss; XRD

* Corresponding author. Tel.: +91-4565-227550; fax: +91-4565-227779.
E-mail address: marutha_m@yahoo.com (S. Maruthamuthu).

0010-938X/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.corsci.2004.05.016

1. Introduction

Microbial contamination of fuels has been the cause of intermittent operational problems throughout the world for many years. Even less then 0.1% of water is enough for microbial activity leading to biodegradation of hydrocarbons. In order to prevent the effects of microbial growth, several lines of approach such as good house keeping practices, treatment with biocides to limit the growth and use of special tank linings, etc. are used. The types and ability of microorganisms to degrade petroleum hydrocarbons have been widely documented [1–6]. The corrosion of carbon steel in oil-in-water under hydrodynamic was studied by Becerra et al. [7]. The influence of inhibitors on the rate and mechanism of corrosion in petroleum product in presence of moisture was studied by various investigators [8–11]. Internal corrosion as a cause for leakage of steel tanks has been documented in US, France, Sweden and Switzerland by various sources [12–14]. Jana et al. [15] carried out a failure analysis study in oil pipelines at Mumbai offshore and concluded that the combined effect of CO_2, SRB, and chloride in the low velocity area caused the severe corrosion and failure of pipeline. Muthukumar et al. [16] reported the degradation of diesel in presence of microbes and noticed the role of degradation on corrosion. But no literature is available on the mechanism of the microbial corrosion in naphtha pipeline. Recently CECRI has noticed severe corrosion problem in a naphtha pipeline at Southwest India. The length of the pipeline was 5.5 km and corrosion products about 10 kg were collected from the pipeline every two months. Large quantity of sludge was noticed in the naphtha storage tank where the disposal of sludge had to be cleared by Pollution Control Board. The microbial growth in the sludge often causes severe turbidity and cloudiness of naphtha. Moreover, sludge often changes the actual chemical properties of naphtha in the storage tank and in transporting pipelines. In the present study, the nature of degradation of naphtha in a pipeline and its effect on corrosion have been assessed and discussed.

2. Materials and methods

2.1. Bacterial enumeration in corrosion product and in sludge

By using sterilized conical flasks, samples of naphtha and corrosion products from the filters and sludge from storage tanks were collected. These samples were transported by using icebox from sites to CECRI, Karaikudi. The collected samples were serially diluted (10-fold) using 9 ml of sterile distilled water-blanks and the samples were plated by pour plate technique. The nutrient agar medium, iron medium, API Broth and Mn-medium were used to enumerate heterotrophic bacteria, iron bacteria, sulphate reducing bacteria and manganese depositing bacteria respectively. The collected samples were serially diluted up to 10^{-6} dilution. One millilitre (1 ml) of each sample was poured into sterile petridishes. The prepared respective sterile medium was also poured into petridishes. The plates were gently