BACTERIAL DEGRADATION OF KEROSENE – TYPE FUEL IN STORAGE TANKS & ITS CONTROL[+]

Wesam Abd-Al-Zhrah Hindi[*]

Abstract

The study was made on sludge samples taken from tanks used to store kerosene-type fuel at al-Dura refinery station, results of this study indicate the following:

1) **Sludge is caused by bacteria & products resulting from bacterial metabolic activity.**
2) **The kerosene-type fuel & the additives (corrosion & gum inhibitors) approved to be used in fuel, are not bactericidal agents, but, the fuel & the additives themselves were found to be nutritive for bacteria.**
3) **A 1.5-2% concentration of sodium tetraborate or a 2% concentration of potassium tetraborate in water bottoms of the fuel storage tanks can produce bactericidal conditions within the tank.**

المستخلص

أجريت الدراسة على نماذج من الوحل الزيتي، أخذت من قاع خزانات حفظ الوقود الكيروسيني في مصفى الدورة ، وأوضحت نتائج الدراسة ما يلي:

١) الوحل الزيتي تسببه البكتريا أو نواتج مرتبطة بالفعاليات البايولوجية لها.

٢) الوقود الكيروسيني وكذلك المضافات (مانعات الصدأ ومانعات المواد اللزجة) والمسموح باستعمالها بالوقود هي مواد ليس لها تأثير قاتل على البكتريا، بل بالعكس أظهرت البكتريا قدرتها على استغلال الوقود والمضافات كمصادر غذائية.

٣) أن تركيز ١,٥ - ٢% من المركب تترابورات الصوديوم و٢% من المركب تترابورات البوتاسيوم في الماء الموجود في قعر الخزانات أظهرت قدرتها في السيطرة على نمو البكتريا وحفظ الوقود

Introduction

During the past years many papers refferred to the malfunctions of refueling equipments of fuel systems in petrolium industry of many organizations that hampered their operations, it was found that the malfunctions are caused by sludge deposits .Samples taken from the water bottoms of the storage tanks gave a quite evident that excessive sludge is present[1,2] , it is surmised that this sludge is introduced from the water bottoms of the storage tanks into other fuel equipments due to the force of suction created by the flow of fuel that agitates & disperses the sludge from the water bottoms into the fuel mass allowing it to pass with the fuel through the water separators & ineffective filters[3,4,5]. The purpose of this work is to devise means of eliminating & preventing any further build-up of sludge in the kerosene-type

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[*] **Assist. Prof /Technical Institute of Babylon**

fuel storage tanks if it is determined that the sludge is of a biological nature or the result of biological processes.

Materials & Methods

1- Detection of microorganisms

Sludge samples taken from water bottoms of fuel storage tanks located at Al-Dura refinery station were examined microscopically using fixed stain & hanging-drop slides. Large numbers of bacteria were found to be present in all samples. Motile bacteria were observed from the hanging-drop slides[6,7].

2- Isolation of microorganisms

The streak-plate method was used to isolate the organisms present in the sludge samples. The Brewer plate method was used with thioglycollate medium in an attempt to isolate any obligate anaerobic bacteria. Dilutions of 1:100.000 were made of the sludge samples with sterile distilled water before it was possible to isolate individual colonies with reasonable assurance of purity. No filamentous fungi nor any strict anaerobic bacteria were isolated[7].

3- Metabolic activity of isolates in the kerosene-type fuel

Bushnell & Haas medium[8] was selected to determine whether the large number of living bacteria were passively introduced into the fuel tanks in large numbers or were organisms capable of utilizing the fuel as a sole source of carbon & energy, seventeen bacterial culture were selected from the original isolates, based on their individual gross morphology & biochemical reaction [7,9,10], seventeen tubes were made with fuel which was free of additives over Bushnell & Haas medium and seventeen tubes containing only Bushnell & Haas medium, each was inoculated with 0.01 ml of 18 hrs. of one of the seventeen inocula, the tubes were incubated at 37^{o}C for 10 days. Bacterial activity was denoted by increased concentrations of bacteria easily determined by comparing each specific tube containing the fuel with it's counterpart containing only Bushnell & Haas medium, since bacteria do n't grow in any of the seventeen tubes containing medium only, any increase in bacterial population within the other tubes was attributed to an essential nutritive ingredient, in this case, the fuel.

4- Antimicrobial properties of fuel additives

Two milliliters of fuel-additive mixture were aseptically titrated into each of seventeen tubes each containing 9 milliliters of Bushnell-Haas medium, seventeen culture tubes containing only the medium maintained for use as controls, all the tubes of each group were inoculated with a loopful from single culture inocula of the seventeen isolates, all tubes were incubated for 10 days at 37^{o}C. The antimicrobial properties of the fuel additives were determined by comparing the individual tubes containing 5% additive-fuel (gum or corrosion inhibitors) to it's counterpart containing only the medium . The effectiveness was interpreted from the obvious differences in concentrations of bacteria between the tubes[7]. However, since no bacterial growth occurred in any of the tubes containing only medium, any increase in bacterial populations in the tubes containing the fuel-additive mixture was attributed to either the fuel or the additive, in either case, it was indicative that the fuel additive was an unsatisfactory bactericidal agent at 5% concentration since it did not completely prevent the growth[11,12].

5- Antimicrobial properties of borates

Nutrient broth was used as the basic, or control medium. The test medium contained the same amount of medium as the control tubes but to which specific amount of borate was added. The bactericidal properties of Na- tetraborate were determined at 1, 1.5, 2% concentrations. The tubes of the control & that containing nutrient medium plus a known quantity of toxicant were inoculated with one of the seventeen inocula, all tubes were incubated for 10 days at 37^{o}C,, any active bacterial growth in any of the tubes containing a toxicant in comparisim to control was indicative that the toxicant was unsatisfactory as a bactericidal agent at that concentration[13,14,15].

Results

Table (1) contains results of evaluations that depict the prominent capabilities of bacteria to produce sludge in the kerosene-type fuel storage tanks. Table (2) indicate the potential of sodium tetraborate or potassium tetraborae to produce bacteriostatic conditions within the storage tanks.

Table (1): Growth of bacterial isolates on kerosene, gum inhibitor & corrosion inhibitor at 37^{o}C for 10 days.

Bacterial isolate	Fuel over B-H medium	5% Tenemene 60 in fuel over B-H medium	5% Paranox 441 in fuel over B-H medium	5% Santolence C in fuel over B-H medium	5% Gulf agent 178 in fuel over B-H medium
Rhodococcus sp.	No growth	No growth	No growth	No growth	No growth
Acinetobacter baumanii	Heavy growth	No growth	Very heavy growth	Very heavy growth	No growth
Sphingomonas spiritivorum	Very heavy growth	No growth	Very heavy growth	Very heavy growth	No growth
Arthrobacter sp.	No growth	No growth	No growth	No growth	No growth
Sphingomonas paucimobilis	Slight growth	No growth	No growth	Moderate growth	Very heavy growth
Pesudomonas fluorescens	Heavy growth	No growth	Very heavy growth	Very heavy growth	No growth
Pesudomonas chlororaphis	Very heavy growth	slight growth	Very heavy growth	Moderate growth	No growth
Brevundimonas vesicularis	Very heavy growth	moderate growth	Very heavy growth	Heavy growth	Heavy growth
Corynebacterium sp.	No growth	No growth	No growth	Slight growth	No growth
Nocardia sp.	No growth	No growth	Slight growth	No growth	No growth
Xanthomonas maltophilia	Very heavy growth	No growth	Very heavy growth	Very heavy growth	No growth
Flavobacterium sp.	No growth	No growth	No growth	No growth	No growth
Flavobacterium spiritivorum	Moderate growth	No growth	No growth	Slight growth	Heavy growth
Micrococcus sp.	No growth	No growth	No growth	Heavy growth	No growth
Agrobacterium radiobacter	Very heavy growth	moderate growth	Very heavy growth	Very heavy growth	Heavy growth
Flavobacterium indologenes	Heavy growth	slight growth	Very heavy growth	Very heavy growth	No growth
Pseudnmonas putida	Heavy growth	slight growth	Very heavy growth	Moderate growth	No growth

Table (2): Antimicrobial properties of different concentrations of Na and K tetraborate in controlling growth of bacterial isolates.

Bacterial isolate	$Na_2B_4O_7$. 10 H_2O in Nutrient Broth			$K_2B_4O_7.5H_2O$ in Nutrient Broth		
	1%	1.5%	2%	1%	1.5%	2%
Rhodococcus sp.	No growth	No growth	No growth	Heavy growth	No growth	No growth
Acinetobacter baumanii	No growth	No growth	No growth	Heavy growth	Moderate growth	No growth
Sphingomonas spiritivorum	No growth	No growth	No growth	Heavy growth	Moderate growth	No growth
Arthrobacter sp.	No growth	No growth	No growth	Heavy growth	No growth	No growth
Sphingomonas paucimobilis	Slight growth	No growth	No growth	Heavy growth	No growth	No growth
Pesudomonas fluorescens	No growth	No growth	No growth	Heavy growth	Moderate growth	No growth
Pesudomonas chlororaphis	No growth	No growth	No growth	Heavy growth	Slight growth	No growth
Brevundimonas vesicularis	No growth	No growth	No growth	Heavy growth	No growth	No growth
Corynebacterium sp.	No growth	No growth	No growth	Heavy growth	Moderate growth	No growth
Nocardia sp.	No growth	No growth	No growth	Heavy growth	Moderate growth	No growth
Xanthomonas maltophilia	No growth	No growth	No growth	Heavy growth	V. heavy growth	No growth
Flavobacterium sp.	No growth	No growth	No growth	Heavy growth	No growth	No growth
Flavobacterium spiritivorum	Moderate growth	No growth	No growth	Heavy growth	Moderate growth	No growth
Micrococcus sp.	Slight growth	No growth	No growth	Heavy growth	Moderate growth	No growth
Agrobacterium radiobacter	No growth	No growth	No growth	Heavy growth	No growth	No growth
Flavobacterium indologenes	No growth	No growth	No growth	Heavy growth	No growth	No growth
Pseudnmonas putida	No growth	No growth	No growth	Heavy growth	No growth	No growth

Discussion

Results of the evaluations performed may indicate that bacteria are the primary causes of the sludge accumulations found in water bottoms of the kerosene-type fuel storage tanks located at Al-Dura refinery station. Eleven of the seventeen bacteria were able to utilize the fuel as an essential nutritive material & cause some changes including emulsification of the fuel, production of gummy residues & themselves formed precipitates in different amounts according to species, that change could easily affect the filters & change of the fuelling & re-fuelling systems[16,17].

Although chemical analyses were not made to detect specific by-products resulting from bacterial metabolism it is quite possible that acid produced by the bacteria attacks the steel storage tank or its lining accounting for the iron salts found in the sludge sample[18]. Some literatures found that steel wool was oxidized much more rapidly in a medium containing a viable mixture of bacteria than steel wool in an identical sterile medium[19,20], although the evaluated corrosion or gum inhibitors gave good results in controlling growth, but it was observed that some bacteria unable to utilize the kerosene-type fuel were capable of utilizing the 5% solution of some additives as a sole source of carbon & energy, it was intented to evaluate these inhibitors at lower concentrations than 5% since this concentration was probably in excess of that considered to be tolerable in fuels due to cost & possible fuel combustion problems[21,22].

In this work we used fuel-insoluble chemicals are used as effective water toxicant to determine whether a particular chemical was a satisfactory to act as biocide against the specific bacteria found to be active in the fuel storage tanks & in concentration that would not form super saturated solutions or crystallization of chemicals when the temperature of the water became near-freezing conditions[23,24].

Some investigators used fuel-soluble chemicals as a biocide, but other complex investigations would have to be made to determine the acceptability of these chemicals with respect to corrosion, fuel combustion, hygene & other properties especially to engines & turbines if the fuel is used in such machines[52,26]. Sodium tetraborate & potassium tetraborate were found to have the required water solubility properties & were screened as biocides against the same seventeen bacteria used in the previous evaluations. A 2% concentration of potassium tetraborate & 1.5% sodium tetraborate were found to be effective in preventing the growth of any of the bacteria originally isolated from the sludge samples obtained from the fuel tanks. So, results of these laboratory evaluations indicate that a relatively easy and inexpensive method could probably be applied to overcome the problem of sludge formations in kerosene-type fuel tanks.

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