Today's Fuels
– Bio Friendly for Man – and for Microbes

E. C. Hill
ECHA Microbiology Ltd

CHANGES IN FUELS AND FUEL HANDLING – CHANGES IN MICROBIAL PROBLEMS

Clever things these microbes. They have been feeding on marine and automotive diesel, gas oil, heating oil and kerosene for decades, and on unleaded petrol as soon as we stopped poisoning them with lead. Now, if they had hands, they would certainly be clapping and thanking us for today's tastier fuel menus. Nicer food means faster growth, and growth equals the slime responsible for filter and injection fouling, and sometimes accelerated corrosion.

Microbes are everywhere, in small invisible numbers, and a sizeable proportion of them can proliferate in the bottom water phase associated with fuels and lubes, and particularly at the fuel/water interfaces in the tank bottom and on wet tank walls. From here, helped by the detergents (bio-surfactants) which they produce, they migrate into the fuel phase. Figure 1 is a sample from a heavily infected gas oil tank. Hydrocarbons provide carbon and energy for growth. Straight chain, branched chain and aromatic hydrocarbons can all be degraded and used as microbial food. Different microbes have different degradative preferences and capabilities.

FACTORS INFLUENCING MICROBIAL GROWTH

As always, water is essential for microbes, and the rigorous removal of free water is a recommended housekeeping strategy to minimise microbial growth in all fuels. The ability of biodiesels to absorb water may be a factor in promoting today's exploding 'epidemic' of infected biodiesels.

Temperature is an important factor. Limited growth takes place below 10°C but above that, growth rate increases with rise in temperature: The optimum temperature varies with different types of microbes but is probably around 28°C. Microbial slime in vehicle tanks, particularly trucks and buses, has been a feature of the current epidemic of biodiesel problems, and this growth may be stimulated if the tanks are in warm locations or just by the warming effect of surplus fuel pumped to the fuel injectors and then returned to the vehicle tank. Possibly we are also seeing an overall influence from climate change, not only on land but also at sea, where fuel cargoes and

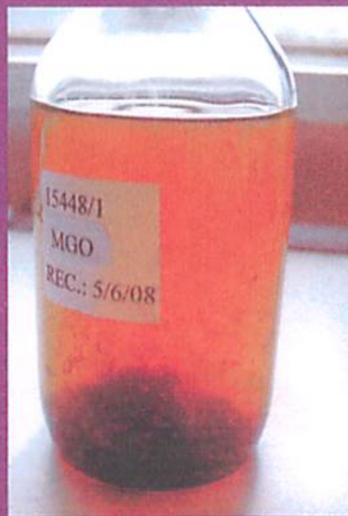

Figure 1. Gas Oil heavily contaminated with microorganisms. Note the turbidit of fuel and soft deposit of microbial growth. When the fuel i disturbed this 'sludge' disperses throughout the fuel.

Figure 2. Truck filter clogged with microbial sludge.

Figure 3. Testing Fuel for Microorganisms Using On-site MicrobMonitor2 test After addition of measured volume of infected fuel sample to bottle of nutrient gel [3a] and incubation, each microbe in the sample has reproduced to form a visible red coloured spot (colony of microbes) [3b]. The number of spots is counted or estimated and is equivalent to the number of microbes in the volume of fuel tested.

ships' bunker tanks equilibrate to the warmer outside sea temperature. Nutrients, containing nitrogen and phosphorus compounds, are essential for microbes, and are sourced from fuel additives, and from ingresses of sea and environmental water. Changes in additives and wetter fuels could be stimulating growth.

NEW FUELS – NEW PROBLEMS

Only a few types of microbes can tolerate and degrade the small molecules in petrol. Lead is toxic to them and there were few operational problems due to growth in petrol until lead was removed – and new additives introduced to boost performance – and in some cases feed more microbes. Petrol/alcohol blends are not usually attractive to micro-organisms. Alcohols migrate from fuel into associated water; if they accumulate at an aqueous phase concentration of more than around 15% v.v., they inhibit all microbes. Propanol is more anti-microbial than ethanol and even more than methanol. At low aqueous concentration, alcohols become nutrients. Like us, different microbes have different tolerances to alcohol.

Fatty acid methyl esters (FAME) are relatively easy for microbes to split up (hydrolyse); the fatty acids formed are then readily degraded for energy and as a carbon source. Most of us have come across rancid fat - FAME degradation is analogous. In our laboratory we have tested many hundreds of samples of biodiesel, from all parts of the storage and distribution chain, including garage forecourts, and end-user tanks and vehicles, and we are finding widespread microbial growth, coupled to operational problems. Figure 2 is a truck filter blocked with microorganisms. We are recording unusual microbial growth everywhere, in all blends of biodiesel. FAME is also now being found in other fuels due to cross contamination during common use of pipe- lines and tanks. The predominant microbial culprits are yeasts. It had been anticipated that the fatty acids in FAME would encourage the proliferation of the highly corrosive Sulphate Reducing Bacteria, which depend on fatty acids as nutrients. However this has not happened, possibly because SRB are averse to oxygen, and rapid fuel turnover aerates fuel and prevents stagnation. Adulterated fuel and unstable fuels are now in widespread distribution and use, and are probably more nutritious for microbes than stable and unadulterated fuels.

ANTI-MICROBIAL STRATEGIES

Anti-microbial strategies should always include good housekeeping and rigorous free water removal has already been mentioned. This should be coupled with allowing adequate settling time, so that both microbes (density about 1.05 gm/ml) and water, can readily be removed. But at many terminals, rapid throughput does not allow this. Prevention of microbiological cross contamination from common use dirty pipe lines and tanks is also desirable, but rarely achievable. Poor tank design is another factor, particularly poorly located and poorly designed drains. If good housekeeping does not work, the next resort is to use an approved fuel 'disinfectant' – a fuel biocide.

Few fuel biocides are marketed in Europe. They must be compliant with the European Biocidal Products Directive, be endorsed by the fuel supplier, and approved by the engine builder involved. They must be fuel soluble so that they disperse in the fuel to wherever the microbes are lurking, and also preferentially water soluble so that they migrate into wet slimes and free water, and kill the microbes there. Dead microbes do not disappear and can still cause filter and injector fouling, sometimes worse than before biocide treatment. Thick slimes are not penetrated by biocides and many microbes will survive. Hence physical or chemical cleaning should take place before a biocide is used in a heavily fouled fuel system.

GrotaMar71 (Schulke & Mayr GmbH) and Kathon FP 1.5 (Rohm & Haas, USA) are two of the most widely used fuel biocides, with widespread endorsements from fuel suppliers and engine builders. They can be used as a shock treatment to decontaminate tanks and facilities, or at a lower preventive concentration to simply suppress growth. Suppliers of biodiesel may opt for preventive biocide dosing, either into the FAME before blending, or into the finished products.

Whichever anti-microbial strategy is used, its success should be validated b an assay for viable microbes. This testing can be carried out by a competent laboratory or can now be performed on site. Routine on-site testing for microbes is also a prudent monitoring strategy.

ON-SITE TESTING FOR MICRO-ORGANISM IN FUEL AND ASSOCIATED WATER

The MicrobMonitor2 test kit, which is recommended by IATA for testing aircraft fuel, is a safe and user friendly on-site test kit. It is quantitative, so trends can be noted, and limit values can be set and linked to remedial actions. It is much easier and safer to kill microbes when growth is just starting than wait until operational problems are occurring. In brief, a measured volume of fuel (or associatec water) is introduced into a small bottle of a nutrient gel which is thixotropic – it liquefies when shaken. The bottle is shaken to mix the sample and gel together and the gel is allowed to rese as a flat layer. The bottle is kept warm or placed in a small incubator, and eacl microbe in the sample reproduces within a day or so into a visible red 'colony'. The number of red spots equates to the number of microbes in the volume of sample tested. The MicrobMonitor2 test is shown in Figure 3. The test is not affected by fuel biocides and can be used to validate the efficacy of biocide use.

CONCLUSIONS

Changes in fuels and in fuel handling have led to a substantial increase in the incidence and severity of problems caused by microbial growth. Many fuel suppliers, distributors, retailers and end-users are introducing monitoring programmes, using on-site or laboratory testing, and successfully implementing control measures.

Others are still wondering what these nasty slimes are and where they are coming from. Hopefully, this article will give them some assurance that they may be growing better fed, fatter, faster microbes, but these are not 'super bugs', and they can easily be detected and then inhibited or killed.

ECHA Microbiology Ltd, Cardiff, tel 02920 496321, **www.echamicrobiology.co.uk**