

Abstract

Cars produce environmentally unfriendly materials such as brake fluid, transmission fluid, and motor oil. There is a need for a reliable method to detect the levels of harmful chemicals that leach into soil and waterways. A quartz crystal microbalance (QCM) is a possible instrument to simply and efficiently monitor and limit both damage to the environment and health hazards that arise from these contaminants. This experiment aimed to determine the ability of a QCM to sense for two hydrocarbons, hexane and heptane, both individually and mixed together. To do this, the three polymers, OV-1, OV-25, and OV-73, were used.

Introduction

Nearly all hydrocarbon contaminants that are in natural water sources are associated with various petroleum products. Some of petroleum hydrocarbons are hexane, heptane, benzene, toluene, xylene, other constituents of gasoline and of other petroleum products^{1,2}.

Petroleum hydrocarbons not only pose risks to the environment but also to human health². Therefore, continuing research regarding petroleum contamination, source, and degradation are vital³. In recent years, hydrocarbons have been discovered in natural water sources. They most likely originated from a variety of natural and human related activities including petroleum use¹. Various vehicles and methods of transportation that burn gas are primary causes of water pollution. Cars are known to leave residues of oil, washing detergents, antifreeze, grease, brake fluid, transmission fluid, motor oil, and remnants of miscellaneous metals on roadways.

Most methods used to determine hydrocarbon concentrations require extracting the hydrocarbons from the water medium such as liquid-liquid, purge/trap, solid phase, and solid microphase followed by gas chromatography or spectroscopy⁴. However, new methods allow direct probing of water for contaminants, such as a QCM. QCM is a very attractive instrument because it is highly selective, cost effective, simple, and has low detection limits.

Experimental

$$\Delta F = \frac{-2F_0^2 \Delta m}{A\sqrt{P_q \mu_q}}$$

Image 1. The Sauerbrey Equation reveals that the change in frequency is linearly proportional to the change of surface mass on the crystal.

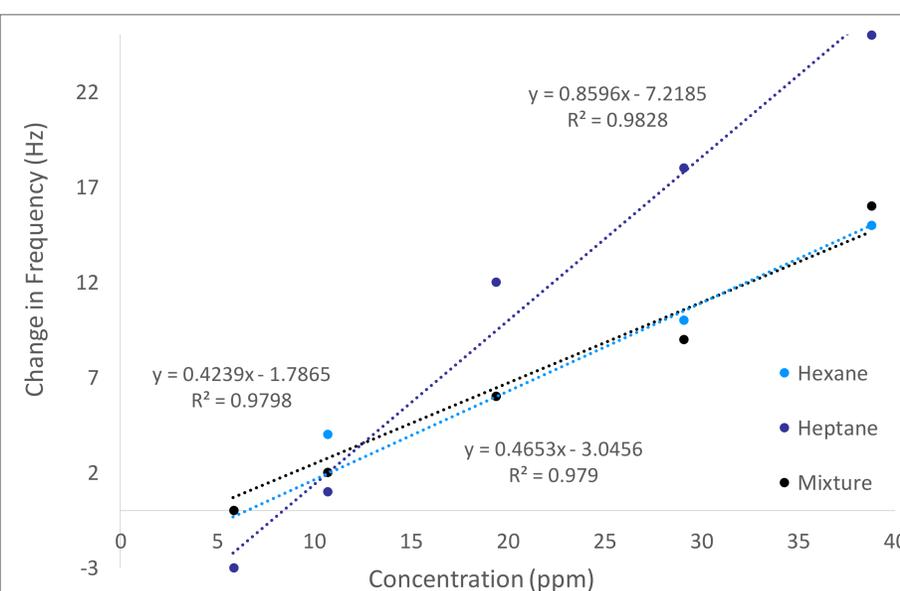


Figure 1. Shows the change in frequency of the crystal coated with OV-73 from the water frequency (Hz) as it relates to the change in concentration (ppm). In order to simplify the Figure, only the data for the hexane concentration in the mixture is shown. This is because the concentrations of hexane and heptane in the mixture were extremely similar.

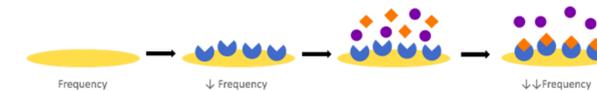


Image 2. A quartz-crystal has an initial frequency associated with it. The surface of the quartz-crystal has a gold coating which can be coated with polymers. When polymers are attach to the crystal, the initial frequency decreases. The polymers are represented in. The polymers can be made very specific so they only attract the target analyte. The analyte is represented in orange, while the additional chemicals in solution are in purple. Once the small masses of interest attach to the polymers the frequency decreases more. This allows for the mass to be determined via the Sauerbrey Equation.

Table 1. Displays the data for the other two polymers tested. The numerical values in the chart are represented of the change in frequency of the crystal from the water frequency in Hertz. In order to simplify the Figure, only the data for the hexane concentration in the mixture is shown. This is because the concentrations of hexane and heptane in the mixture were extremely similar.

Concentration (ppm)	OV-25			OV-1		
	Hexane	Heptane	Mixture	Hexane	Heptane	Mixture
38.7	19	13	22	15	11	16
29.1	16	9	17	9	7	13
19.4	10	4	14	7	2	8
10.6	8	4	8	1	-4	2
5.81	5	-2	4	-2	-7	-1

Results

It was discovered the the QCM was able to detect the solutions of hexane, heptane, and the mixture of the two in a very linear way. This is seen through the R² values that are nearly equal to 1 on all of the graphs. Additionally, all three graphs support the conclusion that the mixture of the two hydrocarbons resulted in a higher frequency than the frequencies of the hydrocarbons when texted individually.

References

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