EFFECT OF TEMPERATURE ON THE SEPARATION OF METHANOL FROM WATER-METHANOL MIXTURE

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Abstract. Many organic compounds may dissolve in water and goes out as waste, these compounds are considered contaminates and should be removed to maintain environment. Many remediation technologies may be used for the removal of contaminates. In this project, air stripping process was selected and to investigate the effect of temperature on the removal of methanol from water-methanol mixture by varying temperature for different feed concentrations and flow rates. The results showed that the effect of increasing the solution temperature has a negative impact for the removal of methanol from a mixture with concentration above 5% methanol.

Keyword. Methanol Removal; Air Stripping.

INTRODUCTION

The reduction of chemical discharge from waste has become a major issue in the chemical and petroleum industries. There are various physical, chemical and biological processes available for methanol removal such as activated carbon, advanced oxidation, membranes and biological treatment. The project is dedicated on observing the effect of temperature in the removal of methanol from water-methanol mixture in waste by air stripping method. Air strippers remove volatile organic chemicals (VOCs) from liquid (water) by providing contact between the liquid and gas (air).

In production of methanol, there are complex reaction are carried out within the reforming processed the catalytic reaction. These complex reaction take considerable time to reach steady state produce the crude, methanol. That suitable for methanol–water separation using the distillation column. The large amount of methanol-water mixture contain methanol less than 10% produce at unsteady state operation will not be suitable for separation by distillation column, ant they send to ground storage tank. May be produce during the shutdown operation this large amount and has to be separation by using other method rather than distillation [3].

There are several treatments for the removal of methanol from water such air stripping, adsorption process, advanced oxidation, membrane filtration, or biologically activated filters [4, 5, 6,7]. However, activated sludge is used widely for the removal of many organic compounds [8], but, little is known about removal of methanol especially using air stripping process. Therefore, the goal of this work was to investigate the removal of methanol from wastewater that produced from methanol plants during the start-up and shut-down operations. Also, this project was designed to test the efficiency of air stripping process to remove methanol from water that contains methanol concentration less than 10%.

Temperature is one of the factors which air stripping depends on it. Hydrocarbon compounds have low boiling points, usually less than 100ºC, and therefore evaporate readily compared with water mixed with. Some are gases at room temperature. In general, VOCs have high vapor pressures, low-to-medium water solubility, and low molecular weights. Their high vapor pressure results from a low boiling point, which causes large numbers of molecules to evaporate or sublimate from the liquid or solid form of the compound and enter the surrounding air. At a given temperature, a substance with higher vapor pressure vaporizes more readily than a substance with a lower vapor pressure. The tendency of a liquid to evaporate is referred to as its volatility. When supplying heat and increasing temperature that means energy is provided to the atoms and molecules, the supplement leads them to vibrate. Hence, separation occurs depending on the difference of boiling points of the mixture's components, the lower the boiling point, the faster the component gets energetic [9].

METHODOLOGY

1. Air stripping Process

Air strippers use equipment to force the air through polluted water. They consist of a large tank filled with a packing material made of plastic, steel, or ceramic. The polluted water sprayed over the packing material by pumping it into the tank. While the water trickles down through the spaces between the packing materials toward the bottom of the tank, the fan at the bottom blows air upward which will pass through the trickling water on the way and by that the chemicals will evaporate. The evaporated chemicals gases will be carried to the top of tank where they are collected and cleaned. The rising air can reach more of the polluted water and evaporate more of the harmful chemicals by spreading the water over the packing material. To make sure that the trickled water to the bottom of the tank is clean, it is collected and tested. If chemicals are still present, the water may be passed through the same or another tank, or cleaned up using a different method. Air strippers vary in size and structure. Some force air across the tank while others do not use forced air. However, they rely on the water trickling through the air in the tank to evaporate the chemicals [10].

Air stripping uses equipment called an air stripper to force air through polluted water. Air strippers may vary in size; structure and the method of functioning. They are designed specifically for the types and amounts of harmful chemicals in the water. The main three types of air stripping are:

- Packed Column Air Stripper
- Sieve Tray Air Stripper
- Diffused Aeration Stripper

2. Experiment

There are four variables affect the efficiency of the diffused aeration air stripping. The variables are temperature, retention time, batch volume, and air flow rate. The experiment is conducted to determine how the temperature parameter effects the removal of methanol from water-methanol mixture containing 3%, 5% and 8% methanol concentration. The experimental set up are shown in Figure. The experimental apparatus consist of:

- An air compressor to produce and control air flowrate .
- Two plastic bottles (humidifiers) are designed according to the amount of water used
- A water bath to heat the mixture in the column.
- A circular air distributor: is designed 8 cm in diameter with holes of 10 mm and a void at the top of the distributor pipe to a length of 1.5 m.
- A cylindrical bubble column: is constructed to conduct batch air stripping experiment. The column is 10 cm in diameter and 1.2 m height.
- A wooden box: is designed to fix the glass tube; this is used in the case of running at ambient temperature.

Figure 1. Experiment set up

3. Experimental Procedure

Several experiments have been carried out at different temperature, different methanol concentrations and different air flow rates. First, water-methanol mixture is prepared at the laboratory; 3%, 5% and 8% of methanol in 1 liter of water. Then, the experiment was run using one methanol solution and at different temperature; 21, 25, 30 and 40˚C. A water bath is used for the purpose of heating the mixture. The air pressure was set to be 2.5 bar and 4 bar for each set of concentrations and temperatures. After that, beside the initial sample, the samples were taken in intervals of 15, 30, 60 and 90 minutes.

Sample analysis was achieved by using FTIR spectroscopy. FTIR stands for Fourier Transform Infrared, the preferred method of infrared spectroscopy.

RESULTS AND DISCUSSION

As mentioned above, several experiments have been conducted to show the effect temperatures on the removal of methanol from methanol-water mixture using air stripping, at different air flow rates. The results are shown in Figures 2 to 7.

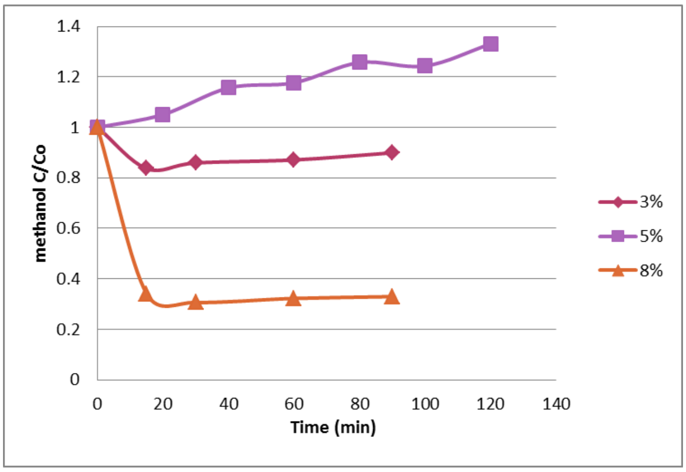

Figure 2. Methanol (ppm) vs. time T= 21.5 ˚C and pressures of 2.5 of 3, 5, 8% concentrations

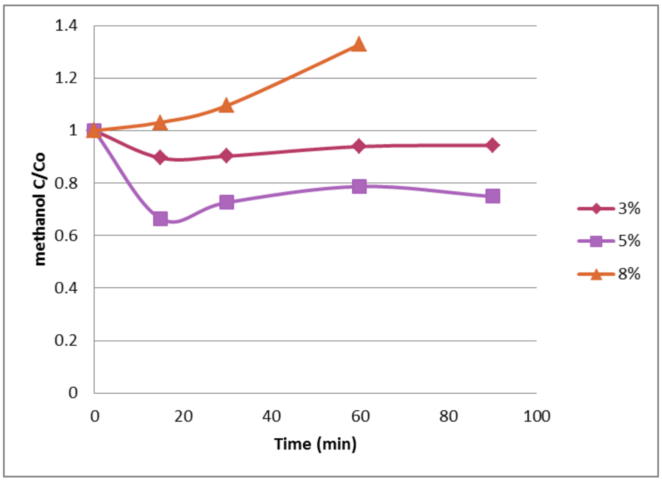

Figure 3. Methanol (ppm) vs. time at constant temperature T= 25 ˚C and pressures of 2.5 of 3, 5, 8% concentrations

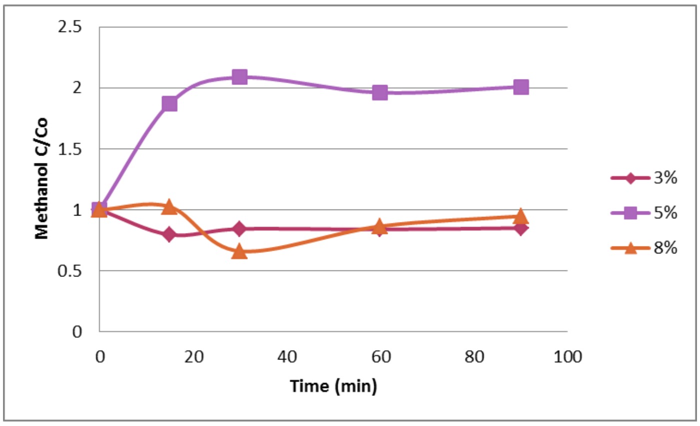

Figure 4. Methanol (ppm) vs. time at constant temperature T= 30 °C and pressures of 2.5 of 3%, 5% and 8% concentrations

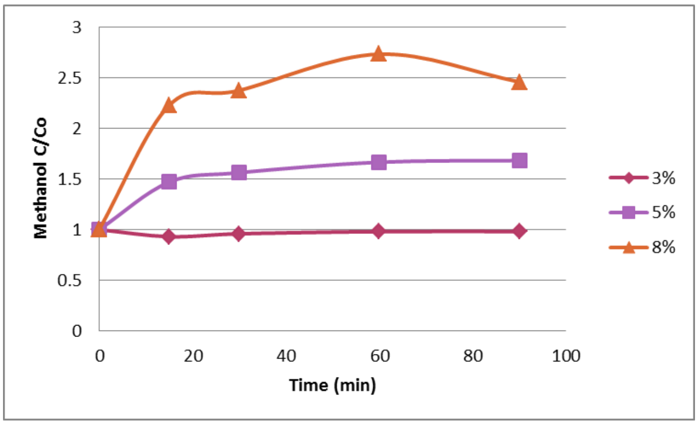

Figure 5. Methanol (ppm) vs. time at constant temperature T= 40 °C and pressures of 2.5 of 3, 5, 8% concentrations

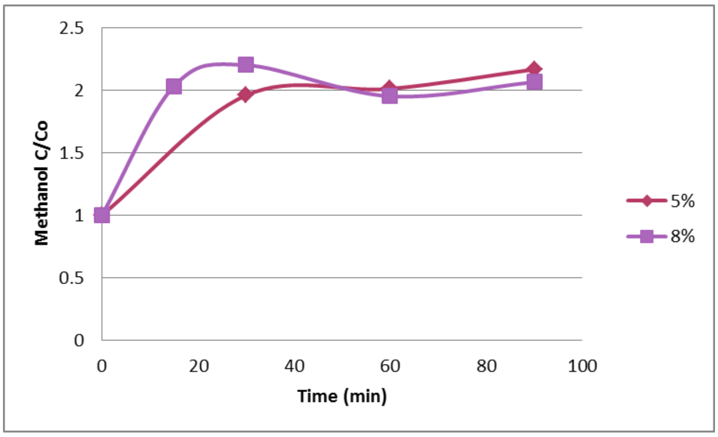

Figure 6. Methanol (ppm) vs. time at constant temperature T= 30 °C and pressures

of 4 bar of 5 and 8% concentrations

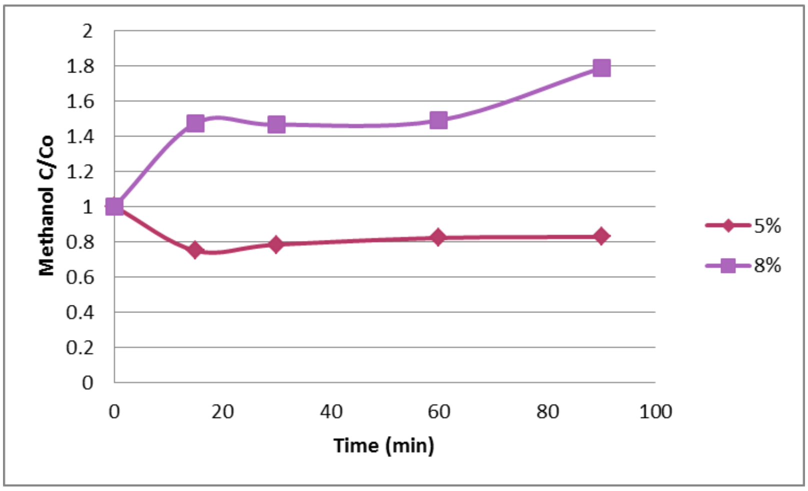

Figure 7. Methanol (ppm) vs. time at constant temperature T= 40 °C and pressures

of 4 bar of 3, 5, 8% concentrations

From the comparison that was made between several tests of air stripping, it can be seen that for 3% methanol concentration at different temperatures. The results show that the methanol concentration in each test is removed at a very short time. Also, it can be seen that the higher the temperature the higher the removal of methanol content (up to 30 °C).

The results show that the methanol concentration is decreased during the air stripping through the column for both high and low air flowrates. However, it can be seen that the lower the air flowrate the higher rate methanol removal. The removal of methanol was high at the beginning of the experiment within a time less than 20 min, then methanol concentration start to increase slightly and then remain at the same concentration, this may be due to the high intermolecular forces between water and methanol.

Results for solution of 5% methanol indicate that the methanol concentration is increasing rather than decreasing, which means that water is removed by air purging more than that of of methanol due to the storage of intermolecular forces and may be due to the surface tension of the solution. Also, it can be seen that there are no much differences between the test using high and low air flowrates.

Increasing methanol concentration up to 8% methanol gave similar behavior to that of 3% methanol. The results show that the methanol concentration in each test is removed at a very short time. Also, it can be seen that the higher the temperature the higher the removal of methanol content (up to 30 °C).

CONCLUSION

Based on this research of air stripper systems that are operating to address methanol contamination, air strippers can be used to successfully and reliably remove methanol from water. This study provides a brief overview of water quality parameters, air stripper design and performance data. Methanol was successfully removed especially at low methanol concentration (ie less than 5%). For methanol concentration greater than 5% can be removed using air stripping process. Increasing temperature up to 40 ^oC cause the evaporation of water rather than methanol, hence, the methanol concentration is increased during the experience

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