RECOVERY SOLVENTS: METHODS AND PERFORMANCES

Adel OUESLATI(1), Mohamed JEMAIEL(2), Rihab YAHYAOUI(2), Leila DRIDI(2)

(1) Higher Institute of Technological Studies Zaghouan-Tunisia
(2) North African Chemical manufacturing, ZI Benarous-Tunisia

ABSTRACT

Organic solvents such as acetone, alcohols, acetates, toluene, etc..are heavily used in the manufacturing industries of paint, inks and semiconductors. They are not only harmful and dangerous to human health and the environment, but are also expensive. They are released as liquid mixtures. Their recovery is a requirement for economic and environmental order. They are recovered in the form of mixtures, usually, colorless processes by simple distillation or flash, by rotary evaporator under vacuum. A novel method of solvent recovery in mixtures, using sodium chloride as an additive, was tested. The results are very important viewpoint of energy saving, the time and ease of implementation.

Keywords: Solvents, recovery, NaCl

1- INTRODUCTION

A solvent is a substance which is liquid at its operating temperature, which has the property to dissolve, dilute or remove other substances without chemically modifying itself without change. Solvents are used in very diverse sectors such as degreasing, paints, inks, detergents, organic synthesis, and represent considerable amounts in terms of raw material and release [1]. Acetone, butanols, acetates, cyclohexane, alcohols and water are found in large quantities in industrial discharges of paint and semiconductors [2, 3, 4, 5]. Their number in liquid discharges may exceed 40. They are toxic and harmful to health and the environment. Handling can result in serious accidents risk [5, 6]. Solvent regeneration uses simple distillation, fractional distillation column and / or distillation by steam distillation to separate the different components of spent solvents. After distillation, the solvents were "dried". The residual water is removed by attachment to a support which does not react chemically with the solvent [4, 7, 8].

The performance of these processing techniques, waste, are limited by the complexity of mixtures of solvents. Indeed these solvents have boiling temperatures neighboring moreover they are
not totally immiscible azeotropic and mixtures thereof are [9, 10, 11]. Hence their separation by distillation and extraction proves not beneficial. Other attempts at separation of a ternary heteroazeotropic mixture was conducted by Stathis Skouras Skogestad and Sigurd. This attempt uses a hybrid extraction-distillation column wherein there is a decanter [12]. This method is beneficial for a ternary mixture, but it is still inadequate for mixtures containing more than three solvents.

On an industrial scale, solvent recovery is effected using a recycling apparatus comprising an enclosure in which the crude mixture is heated by an electric heater. The generated vapors are conducted to a heat exchanger cooled by a condenser-air fan [13]. Sodium chloride was used as an additive for water-containing solvent mixtures, toluene and acetone. The solvent recovery is affected by the evaporation condensation method [14].

In this article, we performed tests recovering solvents using sodium chloride as an additive. The tests are carried out on a rotary evaporator under vacuum. The generated vapors are condensed on the outer walls of a coil. We seek to study the influence of sodium chloride on the amount of solvent recovered as condensate.

2- THEORETICAL BASES

The addition of sodium chloride to a ternary mixture can reduce the boiling point. It can optionally change the relative volatility and the azeotropic composition of solvent mixtures. Furthermore, the salt is used to reduce energy consumption in the distillation process [14].

The effect of sodium chloride on the boiling point of a mixture of isopropyl alcohol toluene-water was confirmed. Indeed the boiling point decreases with increasing concentration of sodium chloride [15]. The same findings were found with a ternary mixture acetone-toluene-water [16].

Sodium chloride is the intermolecular bonds in the solution to make it more fragile. Therefore the boiling temperature and the latent heat of evaporation will be reduced.

![Figure-1: Temperature of pure water and water containing NaCl as a function of time [17]](image-url)
3- EXPERIMENTAL PROCEDURE

Figure 2 shows the diagram of the vacuum rotary evaporator. It is used in the chemical industry to quickly distill solvents, either partially concentrating a solution. The apparatus consists of a balloon to the crude mixture, another balloon for condensate, a glass coil whose inclination is adjustable, a hot water bath where the temperature is controlled by a temperature controller, a system vacuum, a water cooler and the condenser used in a control panel. The positions of the balloons as well as the condenser can be adjusted.

The principle of this device is based on the discontinuous distillation in vacuo. The flask containing the crude mixture is immersed in the hot water bath. It is rotated at a selected rate. The vapors generated are led to the condenser where it condenses on the walls and fall into the coil condensate flask. The cooling water, circulating inside the coil tube, to absorb calories and it moves towards the cooler. Its temperature is controlled by an instruction. The system is evacuated by a vacuum pump.

We will study the effects of the bath temperature, the rotational speed, the initial volume of the crude mixture in the evaporator, the temperature of the cooling water flow rate of the condensate. Concerning the effect of the chemical composition of the crude mixture on the flow of the condensate was examined by comparison with pure water.

![Figure-2: Schematic of the rotary vacuum evaporator used in solvent recovery](image)

4- RESULTS AND DISCUSSION

Figure 3 is a graphical representation of volume of condensate according to the initial volume of the crude mixture. We observe that the quantities of condensate, obtained from crude mixtures containing sodium chloride, mix 1s, 2s mix and mix-3s are higher than those obtained from crude mixtures without sodium chloride, mix 1 mix -2 and mix 3. Crude mixtures containing high levels of volatile solvents and in addition containing sodium chloride produce high amounts of condensate. The addition of sodium chloride to the crude mixture allows an improvement of 20% of the amount of solvent recovered. This is in agreement with the theoretical results claimed by Koller [18].
Figure-3: Volume of condensate according to the initial volume of the crude mixture in the evaporator

Figure-4: Volume of the condenser temperature as a function of the hot water bath

The effect of the temperature of hot water bath on the amount of recovered solvent is illustrated in Figure 4. Crude mixtures for mix 1 mix 2 and mix 3 without sodium chloride, the amount of solvent recovered is below 0.4 liters for bath temperatures between 85 °C and 100 °C.
To the mix-1w mixtures, mix-2s and 3s each mix containing 10 g of sodium chloride, then the amounts of recovered solvent as condensate than 0.4 and can reach 0.9 Liter.

The effect of the rotational speed of the evaporator on the amount of recovered solvent is shown in Figure 5. For mixtures mix 1 mix 2 and mix 3 without sodium chloride, the amounts of recovered solvent is improved with increasing the speed of rotation of the evaporator. But when adding sodium chloride to the crude mixtures to be distilled, the amounts of recovered solvent is improved at least 16%.

**Figure-5**: Volume de condensat en fonction de la vitesse de rotation de l’évaporateur

5- CONCLUSIONS

Recovery of solvents in liquid discharges from factories painting by conventional methods such as distillation, liquid-liquid extraction and absorption is very difficult and expensive. Using a rotary evaporator condenser vacuum to reclaim solvents as condensate is cost effective as long as you choose the operating conditions.

The effects of Initial volume and temperature of crude mixture in the evaporator, rotation speed of the evaporator are studied.

Use of NaCl as an additive in the crude mixture to be separated, allows to increase significantly, the flow of condensate. It also saves the energy required for evaporation.

ACKNOWLEDGMENTS

We thank the directors and officers of the Company Manufacturing NORTH AFRICAN CHEMICAL support and availability.
REFERENCES


[3] André Beguin, Dictionnaire technique de la peinture (3 volumes), Vander


[17] cm1cm2.ceyreste.free.fr/eau_salee.html. 28/08/2012.