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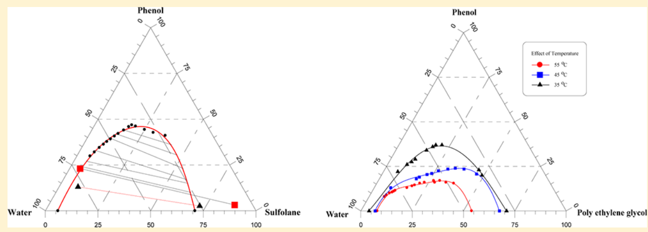
Extraction of Phenolic Pollutants (Phenol and *p*-Chlorophenol) from Industrial Wastewater

Khalid Farhod Chasib*

Chemical Engineering Department, University of Technology, Baghdad, Iraq

ABSTRACT: The efficiency of five new solvents as a selective solvent in the extraction of phenol and *p*-chlorophenol from wastewater was investigated. The phenols samples were collected from real petroleum refinery wastewater and from an experimentaly prepared aqueous phenol solution. In this work, data have been estimated for 10 systems containing, phenol + water or *p*-chlorophenol + water as a common component liquid and + five solvents [ethylene glycol, diethylene glycol, poly(ethylene glycol) (200), dimethylsulfoxide and tetramethylene sulfolone (sulfolane)]. The consistency and accuracy of the tie-line data were evaluated using three correlation relations namely, Bachman, Hand, and Othmer, and Tobias correlation. The Plait Point for each ternary system was estimated. Among the five solvents used to extract the phenol or *p*-chlorophenol from wastewater, diethylene glycol (DEG) has the highest selectivity and distribution coefficient and the greatest differences between its boiling point and density and those of phenol or *p*-chlorophenol. It can therefore, be regarded as an excellent solvent for extracting phenol or *p*-chlorophenol from wastewater. The liquid−liquid equilibrium data have been predicated using the nonrandom-two-liquid (NRTL) model and universal-quasi-chemical (UNIQUAC) model. The binary interaction parameters have been calculated using the Maximum Likelihood Principle technique. The experimental data fitted by the NRTL model are more accurate than the UNIQUAC model.



1. INTRODUCTION

Industrial wastewaters including those from petroleum refining and coking plants contain appreciable amounts of phenols (especially phenol or chlorophenol isomers) which have been identified as hazardous compounds for many aquatic organisms by environmental protection agencies.[1]

Phenols, particularly phenol and chlorophenols can be considered as a serious pollutant of water and soil. They come from the chlorination of water or from industrial and agricultural sources.[2,3] Water that has a concentration usually less than 0.02 mg·L^{-1} of phenols is considered unpolluted water.[4] The level of phenols in dinking water is considered by WHO's guidelines for drinking water quality as 0.001 mg·L^{-1}.[5]

Phenol and chlorophenols are the starting material for many chemical industries. For example, additives for rubber chemicals, emulsifiers, dyes, detergents, adhesives, flavors and impregnating resins are heavily used.[6] Five million tons per year is the phenol worldwide production.[7] It is used for the production of caprolactcam and epoxy resins.[8] The widespread use of chlorophenols as the chlorination of municipal and industrial wastewater and drinking water, degradation products of chlorinated herbicides, wood preservative, the chlorination of lignin or the use of slimicicles in paper or pulp mill plants were the major sources of environmental contamination.[9]

Various methods have recently been applied for phenolic compounds removal like biological-based processes, membrane extraction, distillation, adsorption, ozonation, electrochemical methods, fenton, pervaporation, and liquid−liquid extraction.[10]

If the pollutants are to be recycled, liquid−liquid extraction can be used because it is cost-efficient for the extraction of a wide range of phenol concentrations.

For phenol removal from wastewater, liquid−liquid equilibria data of ternary water−phenols−solvent system are important in the modeling and design of the extraction process.[11]

Solvent extraction is the most economic nondestructive process and has been applied with good results for recovering phenol from industrial effluents when the phenol content in the effluent is above 50 mg/L.[12]

Various wastewater industries have phenols, such as petrochemicals (3.9 mg/L to 1230 mg/L), coking operations (29 mg/L to 3950 mg/L), wood products, paint, pharmaceutical, pulp and paper industries (0.2 mg/L to 1700 mg/L), plastics, coal processing (10 mg/L to 6900 mg/L), and refineries (5 mg/L to 600 mg/L).[13] Several organic solvents, such as diisopropyl ether (DIPE), methyl isobutyl ketone (MIBK), ethylbenzene, cumene, di-isopropyl ether, isopropyl acetate, *iso*-pentyl-acetate, *n*-hexane, toluene, methyl-*iso*-butyl ketone, benzene, *n*-octylpyrrolidone, ethyl acetate, cyclohexane, *n*-butyl acetate, *n*-hexyl acetate, *n*-pentyl-acetate, *cyclo*-hexyl acetate, acetate esters, TBP, and butyl acetate are in common use for recovering the phenolic compounds in the wastewater by solvent extraction technology.[14−16]

It is necessary to study new solvents and new experiments related to the removal of phenolic compounds because the industrial wastewater from petroleum refining and coking plants

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