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Optimization of Phenolic Based De-Emulsifiers

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ABSTRACT

The de-emulsification of a Nigerian crude oil emulsion has been investigated using locally formulated base and acid catalyzed phenol formaldehyde resins with varied formaldehyde to phenol molar ratios. The bottle test method was used for the screening process and the best de-emulsifier was chosen based on the largest volume of water removed from the crude oil emulsion. The screening process was done at temperatures of 50 and 70°C and de-emulsifier concentrations of 20 and 50 part per million (ppm), respectively. A factorial design was done to determine the best combination of de-emulsification conditions for optimal performance. The results were optimized and analyzed using software called Minitab 16 utilizing pareto chart, normal effects, main effects and interactions plots. From the analysis, it was found that the optimum set of conditions for best performance of the resole de-emulsifier were 50 ppm, 70°C and 1.8:1 concentration, screening temperature and formaldehyde to phenol molar ratio, respectively. While for novolak de-emulsifiers, they were 50 ppm, 70°C and 0.1:1. Increasing temperature and concentrations were found to enhance de-emulsification performance with all the resole and novolak de-emulsifiers.

Key words: Resole, novolak, de-emulsifiers, de-emulsification, emulsions

INTRODUCTION

Nigeria oil reserve is abundant and it is estimated to be about 209 billion cubic feet with its net oil export of over 2.5 million barrels per day (Energy Information Administration, 2007). But one of her oil fields-Obagi oil field in Rivers, Port Harcourt is having emulsion problem. The Basic Sediment and Water (BS and W) of the crude oil is 2-12% which makes it higher than the specified 0.5%. This problem makes crude oil produced from this region to have low market value because it is difficult to meet international market specifications.

Water-in-oil emulsions are common occurrences during crude oil production. They are formed when oil and water are co-produced with sufficient agitation or injected water in reservoir, at well bore, in pipelines during flow of the mixture from the reservoir to the manifold and separators and at surface facilities (Al-Sahhaf *et al*., 2009). Emulsion stability ranges from a few minutes to years depending on the nature of the crude oil mixtures (Bhardwaj and Hartland, 1998). Crude oil is a complex mixture of hydrocarbons (Aske, 2002; Rhee *et al*., 1989) ranging from the paraffins to naphthenes and aromatics. It varies in color from clear to tar-black and in viscosity, from that of water to almost solid. It exists in the reservoirs in most cases as gas at the top followed by the oil and then water at the bottom (Hyne, 2001). Hence, during the production of crude oil, water accompanies the oil being produced. It has been reported that an equivalent volume of water accompanies the daily production of some 60 million barrels of crude oil (Ivanov and Kralchevcky, 1997). Owing to the various factors that affect production, a relative amount of this water can become completely dispersed in the crude oil as tiny droplets to form water in oil emulsion where oil is the continuous phase and water the dispersed phase. In most cases, crude oil emulsions result from the natural surfactants such as asphaltenes and resins contained in the crude oil which, when mixed with water, emulsifies the water into the oil (Sjoblom *et al*., 1992). This produces stable water-in-crude oil