

The Role of Bentonite Addition in UF Flux Enhancement Mechanisms for Oil/water Emulsion

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Abstract

The main problem in treating oil/water emulsion from car wash wastewater by ultrafiltration (UF) is fouling caused by oil adsorption on the membrane surface and internal pore walls. This study demonstrates that the addition of bentonite clay can reduce the adsorption layer on cellulose acetate UF membrane, resulting in a reduction of total membrane resistance (R_t). Experiments were conducted to identify and describe three possible mechanisms: (i) bulk oil emulsion concentration reduction, (ii) particle aggregation, and (iii) detachment of the adsorbed gel layer by shear force. Adsorption of oil emulsion by bentonite can lead to a significant reduction of bulk oil emulsion concentration, one of the major causes of flux enhancement. Results show that contact of oil emulsion with bentonite forms larger particles resulting in flux increment. An optimum particle size of 37 μm , corresponds with a bentonite concentration of 300 mg/L and provided the highest flux. Beyond this limiting concentration, flux improvement gradually declined, possibly due to the formation of packed cake of particles on the membrane surface. The presence of bentonite in the oil emulsion promotes high shear stress which acts against the gel layer. This high shear stress, caused by bentonite particles and cross flow velocity, reverses the adsorbed gel layer to the bulk of the liquid phase.

Keywords: Ultrafiltration; Oil water emulsion; Bentonite; Flux enhancement; Membrane fouling; Particle aggregation; Anti fouling.

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1. Introduction

Wastewater from car washing stations contains a number of impurities such as free oil, oil/water emulsion, emulsifier and clay sludge. An average of 600 L of water is generated per car [1] and contains more than 1% oil. The sludge, free oil and a small fraction of emulsified oil is removed through conventional techniques such as the American Petroleum Institute (API) gravitational oil separator, Parallel Plate Interceptor or Corrugated Plate Interceptor. The larger fraction of emulsified oil can not be removed by existing systems. Due to the presence of petroleum hydrocarbons, this wastewater is considered a hazardous industrial waste and requires further treatment prior to discharge into municipal sewers.

In view of the increasing cost and dwindling supply of water, recycling treated car wash is an attractive alternative. In the dust cleaning stage of a car wash, high pressure water is used to spray the car body and engine to remove soil particles. In the foaming stage, an emulsifier solution is sprayed on the car body which then requires a large amount of water to remove during the presoak stage. UF is an attractive process for separating the oil/water emulsion and filtrate water could be recycled for these three washing stages.

The controlling parameter of the UF membrane flux for oil/water emulsion removal is the formation of gel layer adsorption at the membrane and liquid interface [2]. The high operating