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RESEARCH

A Dried Hydrophobic Aquaphyte as an Oil Filter for Oil/Water Emulsions

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In the present study, dead biomass derived from a hydrophobic aquatic plant, a *Salvinia* sp. found in Southern Brazil, was studied as an oil filter for oil/water emulsions. The performance of the *Salvinia* sp. biomass as such was compared to that of a processed peat (Peat Sorb) that is sometimes used as a sorbent for oil. In the utilization of the *Salvinia* sp. and Peat Sorb as filters for oil in oil/water emulsions the results of two equal tests were averaged in order to verify the reproducibility of the experimentation. In the experiments the emulsion was passed through the filters until saturation of the filter was indicated by the appearance of oil in the filtrate (breakthrough). For *Salvinia* sp., the average amount of emulsion passed through the filter until breakthrough was 18.7 l containing 10.61 g oil. The amount of oil retained was 9.53 or 1.33 g oil/g biomass. Thus, 90% of the oil in 18.7 l emulsion was retained by the biomass. The tests using Peat Sorb were performed under the same conditions as for the aquaphyte biomass. The average amount of emulsion passed through the filter until breakthrough was 4.0 l containing 2.68 g oil. The amount of oil retained was 1.66 or 0.26 g oil/g Peat Sorb. Thus, the Peat Sorb retained 62% of the oil in 4.0 l emulsion. The superiority of the *Salvinia* sp. for removing oil from such emulsions, since the surface areas of the two materials are similar, appears to be due to the hydrophobicity and the hair like projections of the surface of the aquaphyte biomass.

Keywords: **Oil/water, emulsion, dry biomass, adsorption, oil filter**

Introduction

The amounts and form of oily wastes discharged from various industries varies considerably (Bennett, 1988). In the petroleum industry a mixture of oil and water is encountered in various stages of production, transport, storage and the refining of petroleum. Such mixtures are sometimes encountered in other industries that use or handle oils. Pumps, valves and other blending devices produce a mixing of the two phases and the formation of oil in water and water in oil emulsions. These emulsions sometimes escape into the environment in effluent streams. It is generally quite difficult to separate oils in these emulsions from the accompanying water. In the present study, dead biomass derived from a hydrophobic aquatic plant, a *Salvinia* sp. was studied as an oil filter for oil/water emulsions. Peats have been studied as a filter for oil/water emulsions (Cohen *et al.*, 1991; Mathavan & Viraraghaven, 1992). Thus, the performance of the *Salvinia* sp. biomass as an oil filter in the treatment of oil/water emulsions was compared to that of a commercially available peat (Peat Sorb) that is sometimes used as an oil sorbent (Ribeiro *et al.*, 1998).

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Materials and Methods

Materials and reagents

For experimentation, samples of *Salvinia* sp. were harvested from the CORSAN dam in Atlantida Sul, Rio Grande do Sul, Brazil. The samples were washed, dried at 60 °C, ground in a blinder to 93% < 4 mm, separated and put in a polyethylene container. The Peat Sorb was obtained from Petrobras and is used by the company to remediate oil spills. The material was < 4 mm in size.

Salvinia sp. are water ferns that often grow explosively in many parts of the world and can become noxious pests (Schulthorp, 1967; Schneider, 1995). Thus, they often must be removed from waterways and lakes by cutting, poisoning, biological attack, or some other means. Since these water ferns are free floating on the water surface, they can be easily removed from the water surface. Further, *Salvinia* sp. can be cultured at a rate of 100 kg/ha/day with a low cost of harvesting, handling and transport (Ribeiro *et al.*, 1998; Reddy & Debusk, 1987). Thus, these macrophytes are attractive targets for use as biosorbents.

The *Salvinia* sp. studied possesses a characteristic surface film that confers the hydrophobicity to the plant. In addition, it contains a felt-like surface consisting of fine "hair like" projections on the plant surface.

The oils employed in the sorption tests were Marlin oil, nujol, and vaseline USP. The Marlin oil (obtained from Petrobras corresponds to heavy crude oil without structural water). Nujol and Vaseline are commercial mineral oils with pure aliphatic properties (as confirmed by infrared spectra of the oils). They possess different viscosities due to the different hydrocarbon chain lengths of their structural hydrocarbons.

Physical and chemico-physical characterization

The apparent densities of the dry materials were determined in a Quanta Chrome helical pycnometer. A gas pycnometer was indispensable for the determination of the density because of the natural hydrophobicity of the material since it was impossible to handle such materials in a standard pycnometer.

The hydrophobicities of the biomass and the Peat Sorb and the tendency of the materials to be removed from the water phase into a non-polar phase were determined by testing the partition of the materials between aqueous and hexane phases. In this experimentation a sample of approximately 1.0 g was placed in a beaker with 20 ml of water and with sufficient agitation. Following this, hexane was added and the beaker agitated for 3 min. The mixture was then let stand for 5 min, the time necessary for separation of the phases. The quantity of material transferred to the organic phase was determined by filtration followed by subsequent drying and weighing. The results are expressed in terms of the proportion of material transferred to the organic phase. These values are estimations of the degree of hydrophobicity (or oleophilicity) of the materials.

The surface areas of the biomass were determined by a methylene blue (Van der Hul & Lyklema, 1968) adsorption method. Equal volumes of 100 ml of solutions of methylene blue of various concentrations were agitated in the presence of 0.1 g of sorbent for 1 h at 30 °C and then let stand for 24 h. The concentrations of the solutions after this time interval were determined using an UV–visible light spectrophotometer, reading at 660 nm. The color change followed a Langmuir isotherm model for mono layer adsorption. The surface area of the sample could then be calculated from saturation adsorption assuming a cross sectional area of the methylene blue molecule to be 108 $Å^2$.

Table 1 shows certain physico-chemical properties of the *Salvinia* sp. and the peat studied.

The viscosities of the oils employed were measured using a de Hoeppler viscometer. The measurements were made in triplicate at 30 °C. The aliphatic oils, vaseline and nujol, had viscosities of 13 and 67 cP, respectively. The Marlin oil, viscosity 237 cP, represents petroleum from a petroleum field site and was supplied by Petrobras. The densities of the oils were determined using a common pycnometer.

Semi-quantitative X-ray fluorescence analyses were performed on the plant biomass and on Peat Sorb. Data obtained indicated that the quantity of inorganic ions in each were quite similar. Biochemical analyses of *Salvinia* sp. and Peat Sorb for greases and fats, proteins and carbohydrates showed that both were of similar value.

Sorption – filtration experiments

These studies were done with the objective of evaluating the sorption capacity and the filtration of an emulsified heavy crude oil (marlin oil) through a filter composed of the *Salvinia* sp. biomass. The results were

Table 1 Characterization of the chemico-physical properties of the *Salvinia* sp. and Peat Sorb

	Moisture content (%)	Density (g/cm^3)	Hydrophobicity (%)	Surface area (m^2/g)
Salvinia sp.	18.2	1.62	93	274
Salvinia sp. (leaves)	11.5	1.47	96	218
Peat Sorb	11.9	1.38	0	270