Pilot-Plant Study of the Adsorptive Micellar Flocculation Process: Optimum Operation and Design

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Introduction

A novel surfactant-based colloidal flocculation process known as Adsorptive Micellar Flocculation (AMF) has been investigated in bench-scale operations[1,2]. Anionic surfactant ions will form micelles in aqueous solution above the 'Critical Micelle Concentration' (CMC); cations are then able to bind onto the surface of the micelles. If the charged anion of a dissociated organic acid pollutant (a process end product or synthetic intermediate), such as the pesticide 2,4-dichlorophenoxyacetic acid (2,4-D), is present, it will associate locally and strongly with the highly positive charge of bound multivalent cations[3]. Because of this association with the micelles, the anionic pollutant is effectively removed from the bulk aqueous solution upon flocculation. In order to further develop the industrial application of this promising water treatment technique, pilot studies are essential. Their aims, which are reported here for the first time, are to establish guidelines for optimum design and operation of a full-scale process. It is a crucial step in establishing the feasibility of scale-up from the bench-scale to a continuously-operated unit at commercial scale. To achieve this aim, a pilot-scale unit has been developed, validated and optimised.

Results and Discussion

The present process can be run as a number of cyclic–batch units running in parallel. Such modification is needed in order to operate the rig as a continuous process. For the system studied, i.e. SDS-Al-phenol, the optimum operating conditions are: residence time for the flocculation reaction of 15-20 minutes; a settling time in a 1 metre-deep reactor of 10 minutes; an air-flow rate is 4.16 litre/min per cubic metre of reactor; an optimum ratio of flocculant to pollutant (weak organic acid) of 0.75. Multi-stage operation of AMF increases the maximum recovery of pollutant. Under optimum operating conditions, the pilot-rig can remove 69% of the pollutant in one stage of operation. This can be incerased to 78% by the use of a second stage of operation. The majority of aluminium and surfactant react under optimum conditions to form flocs; residual dissolved levels in the treated effluent are less than 2.5% of the feed amount. If reagent recycle is employed according to a previously developed strategy, the process may prove to be economically viable.

Conclusions

A number of experimental tests have been conducted to validate the feasibility of using an AMF pilot rig to remove phenol from aqueous effluent streams. Several key factors, including flocculation time, floc settling time, optimum air flow-rate for agitation, and flocculant dosage, were determined. Residual concentrations in treated water indicated a surfactant removal efficiency of 95-98%, and pollutant removal reached 78% in two stages of process operation. A strategy for the separate recycling of surfactant, flocculant and removal has already been developed. The present study has thus made further progress in developing, testing, validating and optimising the operating conditions of a pilot-scale process. As such, it has demonstrated the feasibility of scaling up from the bench-scale to a commercial, continuously-operated unit.

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