OPTIMIZATION OF MICROALGAL BIOMASS HARVESTING USING FERRIC CHLORIDE AS FLOCCULANT

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Introduction. Microalgae are considered as one of the most promising renewable feedstock for biofuel production due to their high photosynthetic efficiency, rapid growth rates and potential for higher oil production per acre than other energy crops (1). Evaluation of several harvesting methods showed that the most promising cost and energy efficient dewatering strategy will most likely utilize microalgal flocculation as an initial concentrating step (2).
The objective of this work was to optimize the flocculation efficiency of *Chlorella vulgaris* under different concentrations of flocculant (ferric chloride) and pH, by using response surface methodology.

Methods. The freshwater microalga *C. vulgaris* (strain P12) was used in this study. Cultures were grown at room temperature and 24 h illumination was provided by fluorescent light at 100 µmol/m^2 s^1 until they reached stationary phase.
A 2^2 full-factorial face-centered central composite design (CCD) was performed as a screening experiment to determine the effect of media pH and flocculant concentration on flocculation efficiency (dependent variable). Flocculant concentration and pH were tested at two levels: i) concentration of ferric chloride ($FeCl_3$): 100 mg/L and 500 mg/L, and ii) pH: 7.0 and 13.0.
Flocculation efficiency of microalgae was calculated by using the following equation:
Flocculation efficiency (%) = (1 – (A-B)/(C-D)) × 100 (1)
where A represents the OD_{750} of sample, B is the OD_{750} of blank (flocculant with H_2O), C refers to the OD_{750} of control and D to the OD_{750} of water.

Results. Results showed that flocculation efficiency of *C. vulgaris* varied under the different harvesting conditions (Table 1). The highest value of biomass recovery (98.1%) was obtained when the flocculation process was performed by using 300 mg/L $FeCl_3$ at pH 10. The experimental values were fitted to a second-order equation obtained by multiple regression analysis. The three-dimensional response surface described by the model equation was depicted in Figure 1. An estimate of the critical point revealed that biomass harvesting can be maximized by using 412 mg/L $FeCl_3$ at pH 9.1.
Assays for validation of this model were then performed under the established optimal operating conditions and the obtained value of flocculation efficiency was 98.5%.

Table 1. Flocculation efficiency of *C. vulgaris* under different pH and flocculant concentration according to the full CCD.

Concentration (mg/L)	pH	Efficiency (%)
300	10	98.0
100	7	53.3
300	10	98.1
300	10	97.5
300	10	97.4
300	13	86.0
500	10	94.9
300	7	95.4
500	7	97.5
100	13	62.7
500	13	92.7
100	10	62.7
300	10	98.1
300	10	97.5

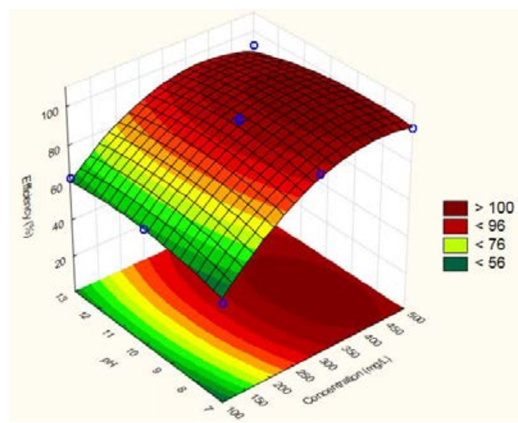

Fig.1 Response surface of flocculation efficiency of *C. vulgaris* as a function of pH and concentration of ferric chloride.

Conclusions. Best flocculation conditions were achieved by using 412 mg/L ferric chloride at pH 9.1.

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