Optimization of Catalyst Design Parameters Using Taguchi Method of Experimental Design

Cem Ozdemir[1], Ayse Nilgün Akin[2], Ramazan Yildirim[1]
[1]Boğaziçi University, Department of Chemical Engineering, 80815 Bebek Istanbul-Turkey. [2]Kocaeli University Department of Chemical Engineering, Veziroğlu Campus, 41040 Kocaeli, Turkey .

Introduction

The ultimate goal in catalyst design is maximization of activity and selectivity of the catalyst. The processes and parameters used in catalyst design affect activity and selectivity via various surface properties such as total surface area, active surface area, metal content, pore structure and so on. Therefore the surface properties should be optimized to obtain desired activity and selectivity. However there are two major difficulties in this task. First the desired combination of surface properties that lead the maximum activity and selectivity are usually unknown and can not be found easily. Second these values of surface properties may not be obtained within the same range of catalyst preparation parameters. To overcome these difficulties a two-step process may be employed. In the first step, the approximate range of catalyst preparation parameters can be found by optimizing various surface properties. Then a more detailed study can be performed within these ranges to maximize activity and selectivity.

On the other hand, catalyst preparation is an expensive and tedious process. Therefore, optimizing surface properties should be considered as "preliminary" and achieved using as small a number of experiments as possible. Taguchi method widely used in industrial experiments may be used for this purpose [1]. Although this method is not suitable for detailed studies, it is very effective for locating approximate optima of design parameters using a very small number of experiments.

In this work, the effects of sol-gel parameters on the total surface area, metal content and activity of Pt-SnO_2/Al_2O_3 catalysts were studied to test the suitability of Taguchi method as an initial step to catalyst design.

Results and Discussion

The catalysts were prepared using sol-gel method [2]. Effects of four sol-gel parameters, namely HNO_3/AIP mole ratio, H_2O/AIP mole ratio, aluminum nitrate concentration, and stirring rate were studied at three levels of each. An L_9 orthogonal array was used requiring the preparation of nine catalysts.

Total surface areas of catalysts were measured by nitrogen adsorption from N_2-H_2 mixtures using the multipoint technique and the BET equation. The metal content were measured by atomic absorption. The activity measurements were performed using microflow reactor system.

The results are evaluated using Taguchi method and optimum values of sol-gel parameters were determined. Then the new catalysts were perpetrated using these values of parameters and results were verified.

It was concluded that Taguchi method can be used to narrow down the range of sol-gel parameters at the initial stage of catalyst design and can help to increase the efficiency of more detailed studies at later stages.

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References

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