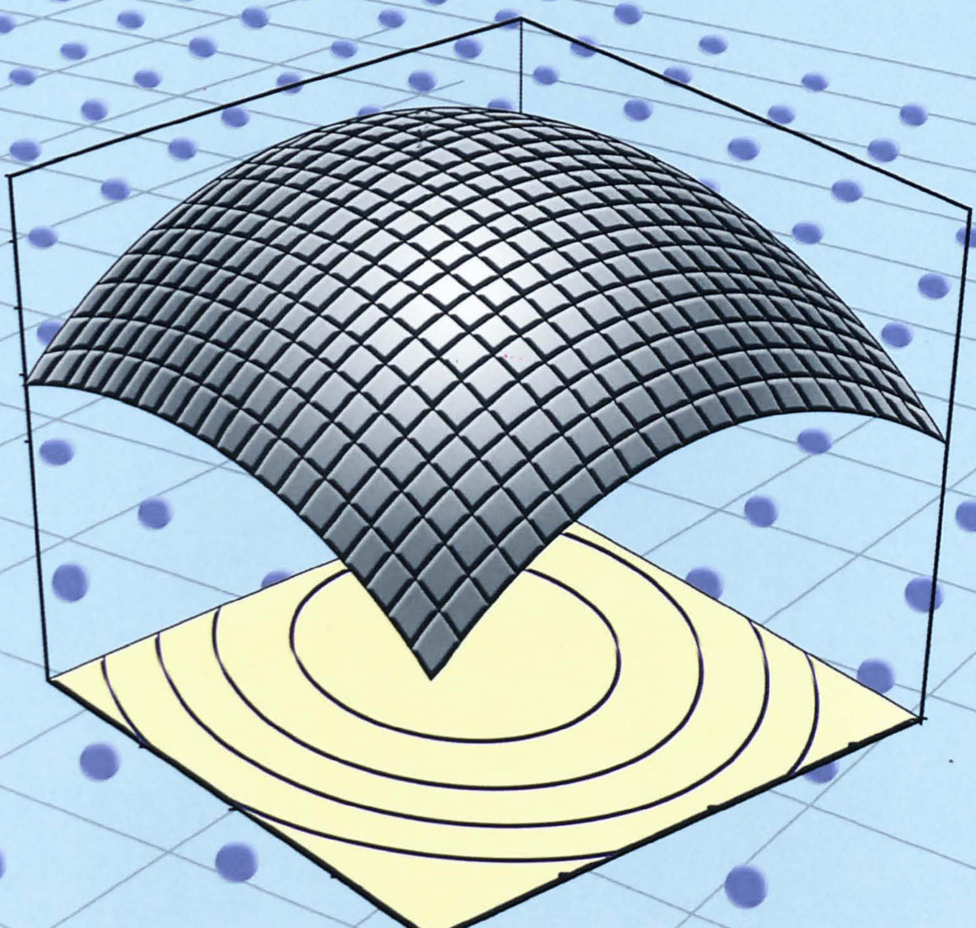
Products and Process Optimization Using Response Surface Methodology



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PREFACE

Response Surface Methodology (RSM) is a set of mathematical and statistical techniques used by researchers to aid in the solution of certain types of problems. The goal of the system of interest is termed as response. This response is normally measured on a continuous scale and is a variable, which likely represents the most important function of the system. Also contained in the system are input variables, independent variables that affect the response. The response surface procedures involve experimental strategy, mathematical methods, and statistical inference which, when combined, enable users to make an efficient empirical exploration of the system in which they are interested.

Industrial process and product formulations are an import subject which plays a crucial role in the quality and process optimization. The RSM is a statistical method that uses quantitative data from appropriate experiments to design and optimize the process and product formulations. The factors that were considered in the usage of RSM are: critical parameters in a system well understood, region of interest where factor levels influencing the product is well known, parameters vary continuously throughout the experimental range tested, a suitable mathematical function relates the parameters to the measured response, and the response defined by the function is a smooth curve.

The important uses of RSM could be to determine the factor levels that will simultaneously satisfy a set of desired specifications; to determine the optimum combination of factors that yield a desired response and describe the response near the optimum; to determine how a specific response is affected by changes in the level of the factors over the specified levels of interest; to achieve a quantitative understanding of the system behaviour over the region tested; and to find conditions for process stability of insensitive spot.

In the design of experiments, some of the problems could arise based on the predictions with degree of uncertainty. It is expected with reasonable prediction throughout the experimental range. The choice of experimental design is affected by the shape of the experimental region.

Based on the software package available, the formulations of the following products and processes were discussed in detail.

1. Formula Optimization of Melamine-Urea-Formaldehyde (MUF) Resin using D-Optimal Mixture Design: Mixture design was used to select points for mixture design in a constrained region. The factors were compositions of resin ingredient. The response to be measured was the physical properties of the formulated resin. The effect of the mixture components on the physical properties of the resin such as viscosity, solubility in water, curing period and storage life was investigated. Finally, optimization of multiple responses was performed in order to obtain a resin formulation with required characteristics.

2. Optimization of Car Shampoo Using D-Optimal Mixture Design: The formulation was based on the composition suggested by D-optimal mixture design. Physical properties of the car shampoo such as pH, foaming ability, power of removal and foaming ability were studied. Finally, optimization of multiple responses was performed in order to obtain a formulation with required characteristics

3. Clog Removal Formulation Using D-Optimal Mixture Design Method: The statistical mixture design for five components was carried out by using D-optimal criterion with upper and lower limit constraints. The effects of mixture components on the cost, physical properties and effectiveness of the clog removal formulation were studied. Finally, optimization of multiple responses was performed in order to obtain a formulation with required characteristics.

4. Studies on the Bonding of Disodium Tetraborate Decahydrate (DTD) with Melamine-Urea-Formaldehyde (MUF) Resin: Mixture design was implemented to study the bonding of Disodium Tetraborate Decahydrate (DTD) pesticide, with various formulation of MUF resin.

5. The Formulation of Non-Stick Insect Repellent Cream with D-Optimal Mixture Design: The formulations were based on the compositions that were suggested by D-optimal mixture design. The effects of the carbopol, TEA, glycerine, water and ethanol compositions on the physical properties and consumer acceptance of the base cream formulation were studied. Numerical optimization was performed in order to obtain the formulation with desired characteristics.

6. Effect of Filler on the Mechanical Properties of Melamine-Urea-Formaldehyde Resin as Wood Adhesive: 14 mix-glue formulations, which include certain percentage of resin, wheat flour and hardener, were generated using mixture design. The RSM responses which include the results data of plywood mechanical properties i.e. plywood tensile/shear strength, wood failure percentage and soak delamination percentage were further analyzed.

7. Optimization of the Natural Ingredient-Based Lipstick Formulation Using Statistical Mixture Design: D-optimal mixture design was applied in order to investigate the relationship between variation composition, physical properties and consumer overall acceptance. Numerical optimization was performed in order to obtain the formulation with desired characteristics at the minimum cost.

8. Selection of Process, Solvent and Drying Method by RSM for Extraction of Antioxidants from Morinda Citrifolia Fruit: Selection of the best process, solvent and drying method was done by the D-optimal method of the RSM. Extraction process, solvent and drying methods were considered as categorical factors and the extraction time as the numerical factor. The response was DPPH radical scavenging activity and the optimum extraction process, solvent and drying method was chosen based on the maximum value of DPPH radical scavenging activity. The results were plotted in the form of interaction graphs between the various extraction process for varying solvent and drying method at varying extraction time. It was observed that the maximum DPPH radical scavenging activity of the extracts were obtained by the extracts obtained from hydrostatic pressure extraction with ethyl acetate as solvent and vacuum dried.

9. High Hydrostatic Pressure Extraction of Antioxidants from Morinda Citrifolia Fruit: Process Parameters Optimization: Optimization of the hydrostatic extraction process for optimum pressure, temperature and extraction time was performed using central composite design (CCD) method of RSM. Pressure, temperature and extraction time were considered as numerical factors. The results were represented in the form of 3D surface and contour graphs. The selection of the optimum pressure, temperature and extraction was based on the maximum value of the response DPPH radical scavenging activity. The numerical optimization was performed by design expert and it was found that the optimum DPPH radical scavenging activity of the extracts to be obtained at 25 bar, 58°C and 5 hours.

10.Optimization of Ultrasonic Extraction Parameters of Iota *Carrageenan* from Seaweed (*Eucheuma denticulatum*): Optimization of the ultrasonic extraction parameter was performed by using central