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A hybrid mathematical model for controlling particle size, particle size distribution, and color properties of toner particles

Maryam Ataeefard[1] · Alireza Shadman[2] · Mohammad Reza Saeb[3] · Yousef Mohammadi[4]

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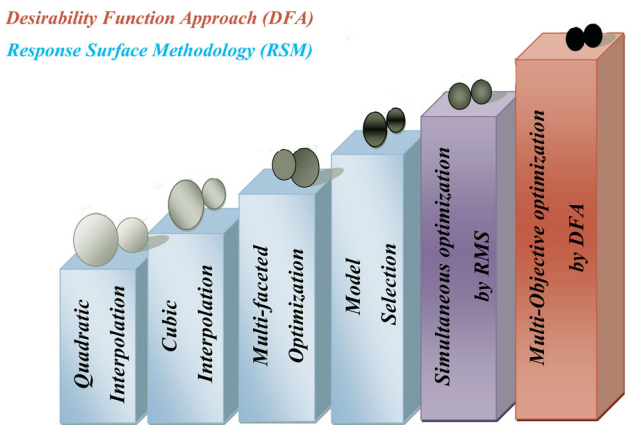
Abstract A mathematical modeling approach was proposed combining the capabilities of response surface methodology (RSM) and desirability function (DF) and implemented successfully in production of printing toner particles. Toner powders were systematically synthesized through suspension copolymerization process. Applying RSM, a series of experiments were designed and toner particles were prepared and the effects of monomer ratio, colorant and surfactant content on the particle size (PS), particle size distribution (PSD), thermal and colorimetric properties (ΔE) of the resulting toner were monitored and discussed. The second-order models corresponding to each target characteristic, i.e., PS, PSD, and ΔE of different types of toner powders, were obtained by individual optimization to express variation of each property in terms of polymerization parameters. Applying statistical calculations, the best reduced models were identified to be fed in the second step of optimization. Since toners with appropriate PS, PSD, and CP were needed, we applied multi-objective optimization based on DF approach. The results show that exact tuning of toner properties is closely possible with the aid of hybrid mathematical model developed in this work. Noticeably, desirabilities are very close to 100 %.

Graphical Abstract



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✉ Maryam Ataeefard
ataeefard-m@icrc.ac.ir

✉ Mohammad Reza Saeb
saeb-mr@icrc.ac.ir

[1] Department of Printing Science and Technology, Institute for Color Science and Technology, P.O. Box: 16765-654, Tehran, Iran

[2] Department of Industrial Engineering, Ferdowsi University of Mashhad, P.O. Box: 91775-1111, Mashhad, Iran

[3] Departments of Resin and Additives, Institute for Color Science and Technology, P.O. Box: 16765-654, Tehran, Iran

[4] Petrochemical Research and Technology Company (NPC-rt), National Petrochemical Company (NPC), P.O. Box: 14358-84711, Tehran, Iran

1 Introduction

Toners are black printing particles based on a polymer resin [mainly poly(styrene-co-acrylic acid)], a colorant (mainly carbon black, Fe_3O_4), and various additives (charge control agent, silica) which are used in digital electrophotographic printing [1]. The merit of electrophotographic printing lies in its relatively low manufacturing cost, convenience, and high quality of produced image over