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Acrylic blends based on polyaniline. Factorial design

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ABSTRACT

Processable conducting materials for large-scale utilization were prepared by mechanical mixing of polyaniline (PANI) paste and commercially acrylic resin. Doped PANI with organic phosphorus acid was synthesized. These blends can be used for the production of semiconductive paints with good corrosion resistance. By mixing doped PANI with commercially acrylic acid (SMP 63 AZUR SA) hard semiconducting and low elastic films are obtain. The effect of four variables was simultaneously studied: PANI (concentration), stirring speed (ST), mixing time (MT), dispersing agent (DA). Due to the number of variables, a factorial-design was chosen in order to reduce the number of experiments required in order to obtain coatings with high hardness and elasticity and semiconductive behavior. The results indicated that the influences of control factors decrease in order: PANI (concentration), mixing time (MT), dispersing agent (DA) and stirring speed (ST). From the studied variables, the resistance is significantly influenced by the two control factors PANI and MT.

1. Introduction

The replacement of classical materials used in industry with other cheaper, environment friendly capable to prevent corrosion is one of the goals in the research area. Electrotechnical industry and engineering needs this special material.

The conductive and semiconductive coatings belong to these special materials and occupy a large application domain in modern industry, used to remove the electrostatic charges, and for the shielding effects (i.e. Faraday screen, protective coat for the high voltage cables, etc.). Conducting polymers have attracted attention due to their electric, optical and thermal properties.

One of the intrinsic semiconductive polymers with useful properties: high conductivity, transparency for the red and violet domain of spectrum, good elasticity and processability, superficial tension, chemical, photochemical and electrochemical behavior, is polyaniline (PANI).

It is known that undoped state of PANI (insulator) is soluble in common organic solvents, but the conducting form (doped form of PANI) is insoluble in almost all solvents, except concentrated sulfuric acid [1–4]. The lower processability is a major disadvantage of PANI. In order to improve the solubility of the conductive form, some routes are possible to overcome these problems: modification of the polymer chain [5], usage of large anions as dopants [6–10] or by dispersing with suitable insulator polymer matrix [11].

The disadvantages of dispersing process are the loss of some mechanical and electrical properties. The main idea is to produce blends that maintain the processability and mechanical properties of conventional polymers and electric properties of the conducting polymers.

The use of PANI as a conductive component in substitution for metallic particles or carbon black, decreases the percolation threshold and can solve some problems, like sloughing (for carbon black) and costs (for metallic fillers) [12,13]. In the field of corrosion protection, conducting polymers especially PANI can be used either as corrosion inhibitors or as protective coatings [14,15].

It is known that blends containing conducting polymers have poor mechanical properties than polymer matrix, in this case acrylic resins [16]. It is desirable for the coating resulted from the paint to present high electrical conductivity and good mechanical integrity (such as scratch resistance).

Some blends based on PANI were studied in more detail through a factorial design [14,17]. In this work, the blending process of chemically synthesized PANI and commercially acrylic blends by mechanical mixing was studied through a factorial design, in order to evaluate the relationship between blend composition-mixing parameter and coating properties.

The purpose of the present work was to optimize various parameters, affecting the mechanical and electrical physical properties of the blends, such as hardness, elasticity and resistance, using an experimental design approach.

The hardness is required in order to obtain a good resistance of coatings under a static load or to scratching and a good cohesion of the particles on the substrate. Films with higher hardness are more effective to support loading and possess less deformation. Elasticity

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Table 1
Composition and characteristics of blends samples.

No. crt.	PANI, %	Dispersing agent, %*	Mixing time, min.	Stiring speed, rot, min.	Particle size, $\times 10^{-2}$ μm	Hardness, min.	Elasticity, mm	Resistance, $\times 10^{-5}$ Ω**
1	5	3	10	500	78	163	2	8.06
2	5	3	10	1000	72	160	2.2	7.12
3	5	4.5	10	500	63	156	2.4	5.85
4	5	4.5	10	1000	55	151	2.6	3.57
5	5	3	40	500	64	157	2.1	2.61
6	5	3	40	1000	61	151	2.3	1.70
7	5	4.5	40	500	56	150	2.6	1.68
8	5	4.5	40	1000	44	149	2.4	1.30
9	15	3	10	500	58	167	2.1	1.15
10	15	3	10	1000	43	164	2.3	0.94
11	15	4.5	10	500	34	160	2.4	0.81
12	15	4.5	10	1000	30	154	2.2	0.68
13	15	3	40	500	36	161	2.1	0.57
14	15	3	40	1000	32	154	2.2	0.48
15	15	4.5	40	500	36	153	2.2	0.41
16	15	4.5	40	1000	30	152	2.1	0.34
17	10	4	25	800	40	158	2.1	3.60
18	10	4	25	800	42	155	2.1	3.15
19	10	4	25	800	43	157	2.0	2.60
20	10	4	25	800	44	154	2.0	1.66

* Represents the total quantity of dispersing agent from paste plus additional amount in blending faze.
** For dispersion.

enables the coating to tolerate and responds to the stresses caused by environmental factors.

The processing parameters like concentration of doped PANI, dispersing additives, rotor speed and mixture time, have a strong influence on coating characteristics. The aim of the study is to obtained coatings with high hardness, good elasticity and with semiconductive properties.

Factorial designs are sufficient to estimate linear, and interaction models and they require a very low number of experimental runs. Some advantages of using a factorial design are based on the

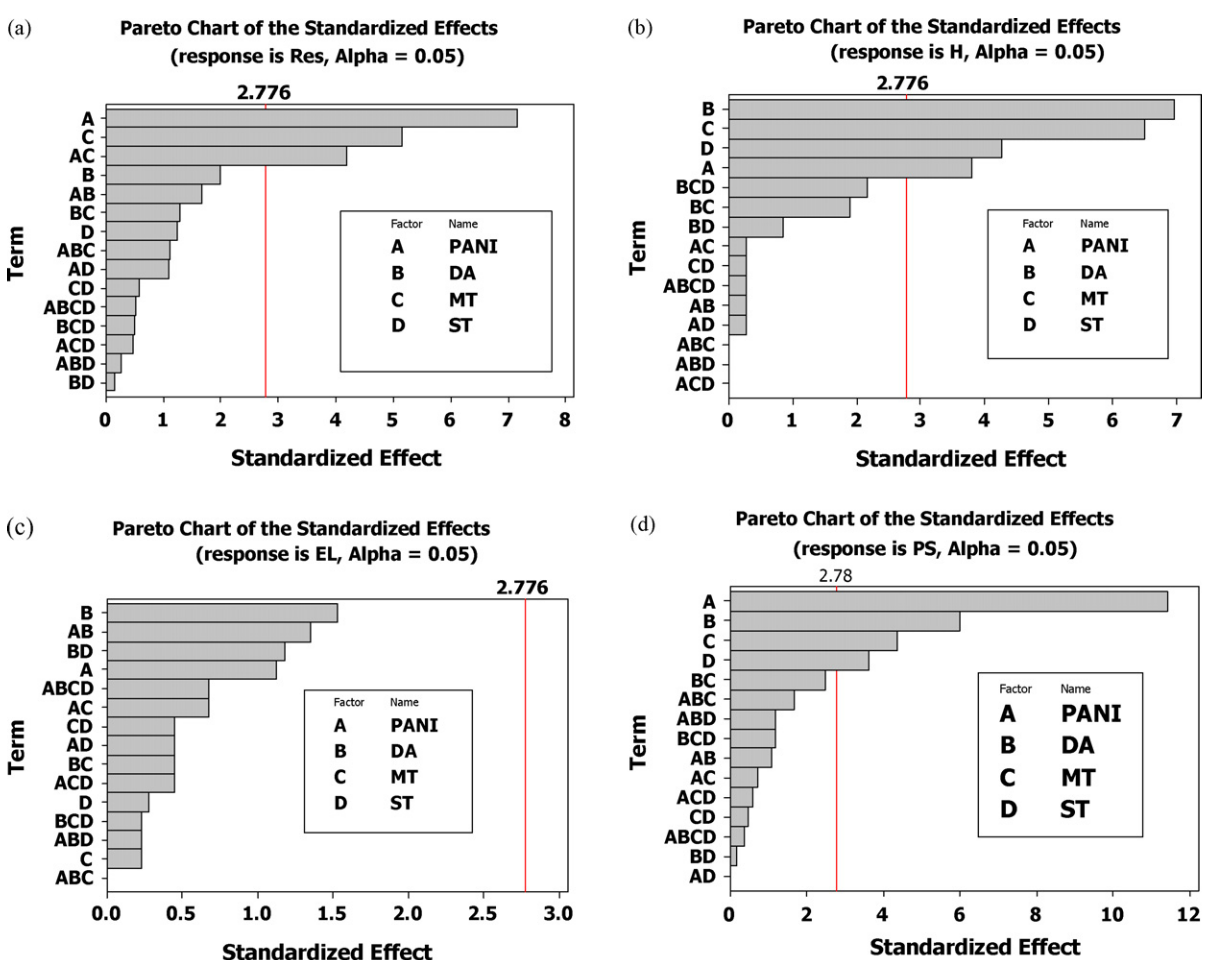

Fig. 1. Pareto chart: (a) Pareto of Res, (b) Pareto of H, (c) Pareto of EL and (d) Pareto of PS.