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The properties of cementitious materials superplasticized with two superplasticizers based on aminosulfonate–phenol–formaldehyde

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Abstract

Two kinds of aminosulfonate–phenol–formaldehyde condensate superplasticizers AS based on sodium *p*-aminobenzenesulfonate and SDMAS based on sodium *p*-*N*,*N*-dimethylaminobenzenesulfonate were synthesized. The properties of cementitious materials superplasticized with the synthesized superplasticizers such as the hydration heat and viscosity of cement pastes, compressive strength and flexural strength of cement mortars was assessed. The results showed that the SDMAS has the stronger ability of inhibiting cement hydration than AS, the initial viscosity of paste with AS is lower than that with SDMAS, the mechanical strength of superplasticized mortars are higher than those of plain mortars at 7 and 28 days, and the mechanical strength of mortars with SDMAS are higher than with AS at 28 days and lower than with AS at 7 days.

Keywords: Superplasticizer; Cementitious materials; Viscosity; Compressive strength; Hydration heat

1. Introduction

The synthesis of new superplasticizers and the mechanism study of superplasticizer molecular and cement particles are still drawing much attention [1–7]. We previously synthesized a water-soluble sodium sulfanilate–phenol–formaldehyde condensate, which exhibits an excellent capability of low slump-loss with time elapsed [1], and has become a popular superplasticizer recently in China.

The aminosulfonate-based superplasticizer molecules contain the amino-group besides the anionic group. The amino-group can form hydrogen bond with the hydroxyl of the water and the oxygen atom on the surface of cement particles, thus influenced the interactions between the aminosulfonate-based superplasticizers molecules and the cement particles. In order to probe into the effect of hydrogen bond on the properties of the superplasticized cementitious materials, two aminosulfonate-based superplasticizers were synthesized. One contains amino-group synthesized from sodium *p*-aminobenzensulfonate, phenol and formaldehyde (AS), another contains dimethyl amino $\left(-N{<}^{CH_3}_{CH_3}\right)$ synthesized from sodium *p*-*N*,*N*-dimethylaminobenzenesulfonate, phenol and formaldehyde (SDMAS). Sodium *p*-*N*,*N*-dimethylaminobenzenesulfonate was synthesized according to the method described in Ref. [8].

In this study, the properties of cementitious materials superplasticized with two aminosulfonate-based superplasticizers such as hydration heat and viscosity of cement paste, compressive strength and flexural strength of mortar at various ages (7 and 28 days) were evaluated.

2. Experimental

2.1. Synthesis of AS and SDMAS

A four-neck flask equipped with a stirrer was charged with desired concentration of sodium *p*-aminobenzensulfonate or sodium *p*-*N*,*N*-dimethylaminobenzenesulfonate,

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phenol and water. The temperature of the solution was maintained at 60–70 °C before the solution is clear, and ammonia was added to adjust the pH value to 8. Then, the solution was heated to 85 °C and a desired amount of formaldehyde was added while stirring, the reaction mixture was stirred under the temperature for 10 h. Thereafter, ammonia was added to adjust the pH value to 11 when the reaction mixture was cooled at 30 °C, and the mixture was stirred for 3 h. Final the polymer solution was added acetone to precipitate the polymer, the powder superplasticizers AS and SDMAS were obtained by desiccation and mortar there solid. The chemical structure of AS and SDMAS are shown in Fig. 1.

2.2. Materials

The cement used was normal 325# Portland cement manufactured by Shandong cement plant, the China ISO Standard sand (Standard sand for strength determination of cement to ISO679 and EN 196-1) was used. The characteristics of the cement are shown in Table 1.

2.3. Evaluation of hydration in cement pastes

The measurement of the hydration heat and the exothermic rate of hydration in cement pastes were performed by TAM Air Thermometric (TC08, Sweden). The mixing amount of superplasticizers on cement mass percent is 0.4% and water/cement ratio is 0.4.

2.4. Viscosity of cement pastes

The cement pastes were prepared by mixing exactly 50 g cement in a beaker together with a constant amount of the AS or SDMAS superplasticizers (0.5 wt.% cement). The water/cement (w/c) ratio of superplasticized paste was 0.40 and the w/c ratio of plain cement paste was 0.45. During 120 min of hydration time, the viscosity of different cement pastes were measured by a viscometer with 100 rpm (DV-II+, Brookfield, USA).

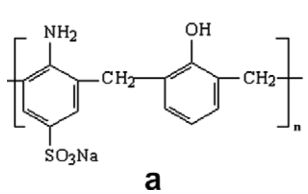

Fig. 1. The molecular structures of AS and SDMAS ((a) AS; (b) SDMAS).

Table 1
Characteristics of cement

Characteristic	CaO	SiO_2	Al_2O_3	Fe_2O_3	MgO	SO_3	Loss
Mass%	52.60	23.08	8.82	1.97	4.43	–	8.12

2.5. Adsorption measurement

A serious of AS and SDMAS solution with different concentrations were prepared, and cement was added according to a water/cement ratio of 2.0. After stirred 15 min, the solution was centrifuged by ultracentrifugation to separate the cement particles, dilute the supernate. Superplasticizer concentration in the solution was measured by UV–visible spectrophotometer (Shimadzu UV-2450, Japan). The absorbing amount was calculated from the differences in the concentration of the solution before and after adsorption.

2.6. ζ-Potential measurement

According to a water/cement ratio of 50.0, the cement and the solution containing the superplasticizer were mixed by hands for 5 min. Taking the upper suspension, the ζ-potential of cement particles was measured by Nano-ZS ζ-potential meter (Malvern, UK).

2.7. Preparation and test of mortar

Preparation and test of mortar were carried out according to GB/T 8077-2000 and GB/T 17671-1999 (ISO). Three $40 \times 40 \times 160$ mm prisms were used for the compressive strength and the flexural strength test. Mix proportion of mortar is given as following: cement/sand = 1:3, fluidity = 180 ± 5 mm.

3. Results and discussion

3.1. Influence of superplasticizers on cement hydration

Figs. 2 and 3 represent the exothermic rate and hydration heat of plain and superplasticized pastes. Compared to the plain cement, the induction period of cement hydration

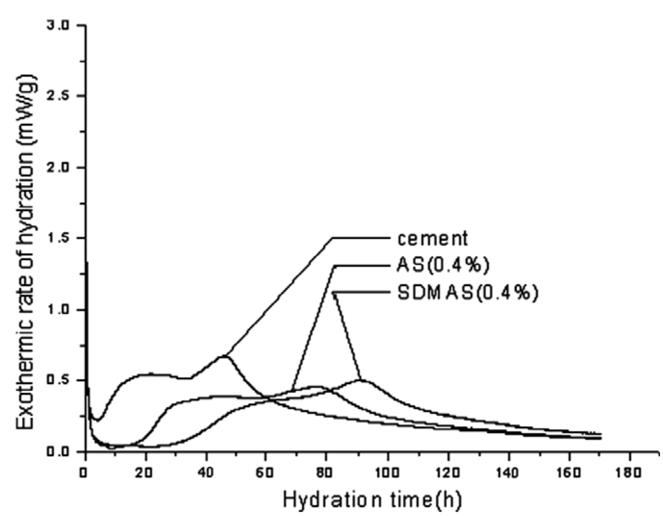

Fig. 2. Relationship between exothermic rates of superplasticized pastes and plain paste with hydration time.