Modification and Application of the Polysiloxane with Amino Groups

Kong-Liang Xie*, Lei Xu, Ya-Qi Shi

Modern Textile Institute, Donghua University, 1882 West Yan-an Road, Shanghai 200051, China

Abstract: A series of the polysiloxanes modified with amino groups are synthesized. FTIR, 1HNMR are used to characterize the polysiloxane structure. Surface properties of the polysiloxane materials with amino groups are discussed. The results show that the polysiloxanes modified with tertiary amino groups had good flexibility and repellency to water. With increasing the amino value of the polysiloxanes, the flexibilities of the fabrics treated with the emulsion were improved. After the samples were treated with the polysiloxanes, the thermal yellowing had emerged. The whiteness of the fabrics treated with the polysiloxane decreased. The reflectance spectra of the fabrics treated without and with the modified polysiloxanes had not significant change.

Keywords: synthesis, modification, surface properties, fabrics, reflection

1. Introduction

Many silicone compounds are able to reduce the surface energy of materials, which is responsible for many applications. The origins of these unusual and useful properties are closely related to silicones' unique chemistry [1-3]. The hydrophobic character of Si-O segments is well known and commonly used in water repellency. They have received much attention for its attractive properties of good water repellency, lubricity, high flexibility, excellent thermal stability, oxidation resistance and climate resistance, etc. Linear polydimethylsiloxane fluid is one of important industrial silicones. Properties, such as low surface tension, water repellence, and high thermal and chemical stability, make silicone fluid-in-water emulsions useful for impregnating surfaces, as antifoaming agents, fabric softeners, and in many personal, automotive and household care products. The polysiloxane modification using functional polymers or compounds has become increasingly important for a wide range of application [4-6]. The aminofunctional polydimethylsiloxanes open a new dimension for textile softening. They confer high lubricity to the fiber owing to their low surface energy. Aminofunctional groups which are bound to a polydimethylsiloxane backbone improve the orientation and substantivity of the silicon on the fiber. The improved orientation of aminofunctional silicone leads to an extremely soft handle [7-10]. When polyorganosiloxane is modified with amino and hydroxy groups, the modified polyorganosiloxane could form thin film of low reflectance index to change material surface properties. The low reflectance materials have wide application in the color fields [11, 12].

Some of the polysiloxane materials modified with primary or secondary amino group are synthesized. They are frequently named as “supersoft”. However, the polysiloxane materials modified with primary or secondary amino group cause the thermal yellowing. The thermal yellowing is of oxidation decomposition of the amino group forming chromophoric group. By comparing the effects of primary, secondary, or tertiary amino, it is clear that whiteness and water absorbency is improved with increasing the degree of substitution, from primary to tertiary. To improve the whiteness and decrease the thermal yellowing have been studied [13,14]. It arises partly from the chemical structure of the amino functional groups.

The polysiloxane modified with functional groups may also be prepared through ring-opening polymerization. All the polysiloxane molecules are insoluble in water. The water-based textile finishing process necessitates the development of adequate polysiloxane emulsions or microemulsions.

* Corresponding author's email: klXie@dhu.edu.cn

Emulsification technology of polysiloxane is very important for its application. The ideal emulsifying agent is the one which is destroyed or rendered inter during the processing of the fabrics. One of the key factors in emulsion stability is proper choice of emulsifier. The selected non-ionic surfactants were used to prepare microemulsions containing more than 30% silicone softener. They can be diluted to the application and provide a soft handle.

In this paper, a series of the polysiloxane materials modified with tertiary amino groups are synthesized through ring-opening polymerization. The emulsions of the modified polysiloxanes are prepared. Some surface properties of the polysiloxane materials are investigated.

2. Experimental

2.1 Materials

Octamethyl cyclotetrasiloxane (D_4) was obtained from Xinghuo Petrochemical Plant of Jiangxi and fractionated under the reduced pressure before used. N, N - (γ-dimetylamino-propyl)-γ-aminopropyl dimethoxysilane (121) was obtained from Zhejiang Dadi Chemicals Co., Zhejiang. KOH (the catalyst of D4 polymerization) and other chemicals used were obtained from Shanghai Chemical Reagent Plant, Shanghai. Scoured polyester fabrics were obtained from Zhejiang Jinqiu Textile Company, Shaoxing, China.

2.2 Synthesis of The Polysiloxanes Modified with Tertiary Amino Groups

D_4 and KOH were added into the reactor and sufficiently mixed with stirring at room temperature. The polymerization mixture was heated to 85°C for 60 min in nitrogen atmosphere. Then N, N - (γ-dimetylamino-propyl)-γ-aminopropyl dimethoxysilane was added into the reactor according to the ingredients (shown in Table 1). The mixture was heated to 120°C. The polymerization was conducted at 120°C for 7 h. The copolymer was fractionated for 30 min under the reduced pressure. The polysiloxane material modified with tertiary amino side chains was achieved.

Table 1 Ingredients and yields of the polysiloxanes modified with tertiary amino groups [gram]

Samples	D4	121	KOH	Yields [%]
1	98	2	0.5	89.80
2	95	5	0.5	90.76
3	90	10	0.5	88.04
4	80	20	0.5	92.53

2.3 Preparation of The Emulsions of The Polysiloxane with Tertiary Amino Groups

The emulsion agent (nonionic surfactant NP-9), 15 g, was dissolved in 105 ml water. The modified polysiloxane, 30 g, was added and sufficiently mixed with stirring at room temperature for 2 h. The translucent emulsions containing modified polysiloxane, 20%, were achieved. The translucent emulsions according to the ingredient were called S-1, S-2, S-3 and S-4, respectively.

2.4 Aftertreatment

The scoured polyester fabrics were padded with the solutions of 30 g/l polysiloxane emulsions to give 75% wet pick-up. The dry temperature and time were 95°C and 3 min, respectively. The cure temperature was 165°C and cure time was 1.5 min. In order to compare, the sample without the aminofunctional polysilixane was cured under the same condition.

2.5 Measurements

FTIR spectrum of the copolymer was measured by NICOLET 20 DXB FTIR. ^{1}HNMR spectrum was recorded on a Bruker AV 400 (Bruker Co., Faellanden, Switzerland). The contact angle was measured using an automatic video contact angle testing apparatus OCA 40 (Dataphysics Co., Germany). The whiteness of the fabrics were determined by Datacolor SP600$^+$ spEctrophotometer (datacol/r, USA). The handle of the samples was tested according to ASTM D1388 test method [15].