



Improvement performance of soft asphalt for coating applications



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HIGHLIGHTS

- This study aims to prepare coating materials based on asphalt cement AC 60/70 which is good adhesive and inert to most chemicals.
- AC 60/70 was mixed with blown asphalt of type 115/15 to produce a basic asphaltic material suitable for coating then it was modified using polypropylene (commercial grade) and unsaturated polypropylene ester prepared in lab.
- Change in weight and compressive strength before and after coating was recorded and compared to commercial coating one.
- Finally, it is concluded that, the prepared coatings are suitable for mortar coating as coating and sealer.

ARTICLE INFO

Article history:

Received 25 March 2016

Received in revised form 28 September 2016

Accepted 6 October 2016

Keywords:

Asphaltic coating

Polymer modified asphalt

Commercial polypropylene

Unsaturated polypropylene ester

ABSTRACT

This study aims to prepare coating materials based on asphalt cement AC 60/70 which is good adhesive and inert to most chemicals but it has unacceptable time to form solid film. In this research, AC 60/70 was mixed with blown asphalt of type 115/15 to produce a basic asphaltic material suitable for coating then it was modified using polypropylene (commercial grade) and unsaturated polypropylene ester prepared in lab. The coatings were applied on prepared mortar cubes for studying their performance comparing to commercial one. The study revealed that the prepared coatings performed much better than that commercially produced.

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1. Introduction

Asphalt (referred to as bitumen) is produced from both nature and distillation of crude oil. It is defined according to American Society for Testing and Materials (ASTM) as a dark brown to black cementations material in which the predominating constituent is bitumen. Asphalt has complex chemical and physical composition, which usually vary with the source of the crude oil, and is produced in refineries to certain standards of hardness or softness in controlled vacuum distillation processes [1,2].

Despite its complicated composition, asphalt is a well-known natural material for numerous applications as paving, lining and insulating [3–5]. Sometimes asphalt must be modified to be suitable for use in some applications. The modifiers may be antioxidants, antirutting, carbon black, hydrocarbon oils,etc [6].

Polymers the most known materials used in small percentages for asphalt modification, can be divided into three groups including thermoplastic elastomers (e.g. styrene butadiene styrene (SBS) and crumb rubber (CR)), plastomers (e.g. ethylene vinyl acetate (EVA) as well as polyethylene (PE)) and polymers with chemical reaction [7–10]. However, olefinic polymers are very good candidates to be used in asphalt modification. They are available in large quantities with different mechanical properties and low cost. The most famous types of polyolefins used are polypropylene (PP.) and polyester (PE.) but, the obtained polymer modified asphalt has low storage stability at high temperature. However, the modification of the olefinic chain by addition of functional groups allows the improvement of the miscibility between polymer and asphalt. They can bright a high rigidity to the material. As a consequence, the presence of the polymer mainly does not really change the viscoelastic behavior of the blend. However, asphalt and asphalt modified polymers can be used as adhesive and coating materials in infrastructure applications [11,12].

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In case of physical mixing of asphalt and polymers, when a low polymer concentration is used, the resin component of asphalt can probably stabilize the dispersed polymer – rich domains, and some “filler-effect” is obtained. On the contrary, at higher concentration, a swelled polymer-rich phase creates a network that significantly influences the viscoelastic properties [13].

For some applications, asphalt is mixed with small quantities of reactive polymers that act as modifiers and strongly enhance its storage stability and physico-mechanical properties via chemical link between polymer and asphalt micelles [14–16].

The aim of this study was to prepare asphaltic coatings (cold applied type) based on asphalt cement AC 60/70 for concrete structure using two types of polymers namely; commercial polypropylene and synthesized 1,2 propylene glycol-maleic anhydride polyester with a special type of prepared solvent. The performance of the prepared coatings was compared to a commercial one. The research results revealed that, the prepared coatings have better performance than the commercial one. Also, AC 60/70 can be used in applications other than paving.

2. Materials and methods

2.1. Materials

Penetration graded asphalt cement AC 60/70 and blown asphalt (BA) of type 115/15 were obtained from Al-Nasr for Petroleum Processing Company (NPC), Egypt. the characteristics of asphalt types are illustrated in Table 1.

- Maleic anhydride, 1,2-propylene glycol, p-toluene sulfonic acid, styrene & solvents were obtained from Aldrich Chemical Company.
- Polypropylene supplied from sigma – Aldrich Company, Germany. It is a linear structure based on the monomer C_nH_{2n} . Most polypropylene used is highly crystalline and geometrically regular (i.e. isotactic). Used polypropylene has the following characters; hardness (18 dm (Penetrometer, ASTM D 5)), viscosity (10 poise (190 °C, Brookfield Thermosel), transition temp (T_g –10 °C) and softening point 155 °C (ring and ball, ASTM E 28) & density (0.9 g/mL at 25 °C) and high operational temperatures with a melting point of 160 °C.

- Commercial asphaltic coating (cold applied) under the trade name INSUPRIMER produced by Manufacture Insulating Material & By-products Co., Egypt has properties complying with ASTM D 41 as illustrated in Table 2.

2.2. Methods

2.2.1. Synthesis of polyester

The unsaturated polyester was prepared by reacting one mole of maleic anhydride with 1.1 mol of 1, 2 propylene glycol using p-toluene sulfonic acid as a catalyst in an amount of 1% of total weight of reactants. The polyesterification reactions were carried out by heating the mixture to a temperature of 50C, then the temperature was raised gradually up to 180C, and heating was continued for 2 h. The reaction was followed by monitoring the volume of water obtained. The unsaturated polyester was yielded as a yellow viscous liquid then it was dissolved in 30% styrene and characterized by Fourier Transform Infrared spectroscopy (FTIR) according to ASTM E 1252/2013 as shown in Fig. 1 using Mattson- Infinity series FTIR Bench Top961. The spectra was measured in the range of 4000 – 400 cm by summing 32 scans at 4 cm resolution and 32 background scans., Proton Nuclear Magnetic Resonance spectroscopy (1H NMR) was carried according to ASTM E 386/2014 as shown in Fig. 2 using a 270 MHz spectrometer W-P-270 & Y Bruker and Gel and Permeation Chromatography (AGPC) according to ASTM D 6474/ 2012 using water model 600E.

2.2.2. Preparation and characterization of the basic asphaltic materials for coating

AC 60/70 was modified by BA 115/15 to suit dampproofing and water proofing applications according to ASTM D 449/2014. AC and BA were heated to temperatures up to 90 °C and 110 °C respectively above their softening points. Blown asphalt was added for AC in percentages of 15, 20 and 25% (w/w) separately. The blends were heated for 15 min with mixing using a rotating mixer at 500 rpm and then left to cool in ambient temperature before they become ready for use. The prepared blends were analyzed for physical characteristics as illustrated in Table 3 and for FTIR as shown in Fig. 3. The blends were applied on glass panels to define the final drying time (ASTM D1640/2003) and the results are illustrated in Table 4.

Table 1
Characteristics of asphaltic materials used.

Characteristics	ASTM standard	BA	AC 60/70	Egyptian	Standard
				BA ^a	AC 60/70 ^b
Penetration(@25 °C,100 g,Ss),0.1 mm	D5	13	67	10/20	60/70
Softening Point (Ring &Ball), °C	D36	114	48	110/110	45/55
Penetration Index (PI)			–0.612	+2	–2;+2
Kinematic Viscosity (@135 °C),c.St	D2170	NS ^c	330	NS ^c	+320
Ductility (@25 °C,5 cm/min),cm	D113	7	+100	+3	+100
Flash Point,(Cleveland open Cup), °C	D92	320	280	+200	+250
Thin Film Oven Test	D1754	ND ^d		NS	
– Retained Penetration (% of original)			48	NS	>52
– Loss on heating,% by wt			1.5		<0.8
Thermal Gravimetric analysis (TGA) [13]					
– Initial decomposition temp., °C		300	215	NS	NS
– Final decomposition temp., °C		810	680		
Chemical constituents	D3279			NS	NS
Oils (%wt)		20.1	23.3		
Resins (%wt)		35.6	54.9		
Asphaltene (%wt)		44.2	21.7		

^a Standard for “General Authority for Roads, Bridges & Land Transportation, Egypt”, Item No 102.01.

^b Standard for “Egyptian General Organization for Standarization and Quality No 195/2008.

^c ND Not Determined.

^d Not Specified.

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