International Journal of Advance Research in Science and Engineering
Vol. No.6, Issue No. 09 , September 2017
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

CHEMISTRY OF POLYMER MODIFIED BITUMEN – A REVIEW

Bindhu Bernard

Assistant Professor, Dept of Civil Engg, S C T College of Engg, Thiruvananthapuram (India)

ABSTRACT

Bitumen is the residue obtained from the vacuum distillation of crude petroleum, which is a complex mixture of organic molecules of different sizes. The thermo-rheological behaviour of bituminous binders depend largely on the chemical structure. While adding modifiers to the bituminous binders, the polymer modification is proved to be of better in improving the structural properties in the field and in the lab. The paper reviews about the various non-destructive tools to analyse the chemical nature of modified bitumen.

Ke words: fluorescent microscopy, gel permeation chromatography, infrared spectroscopy, polymer modified bitumen

I. INTRODUCTION

Bitumen is the residue obtained from the vacuum distillation of crude petroleum, which is a complex mixture of organic molecules of different sizes. The thermo-rheological behaviour of bituminous binders depend largely on the chemical structure. While adding modifiers to the bituminous binders, the polymer modification is proved to be of better in improving the structural properties in the field. Polymer modified binders have had proven success in the field and the laboratory, and a continuing effort is being made to develop a correlation between results from laboratory tests and field performance. [8] By using non-destructive imaging tools, we can study the morphology of polymer modified bitumen or any modification to base bitumen. The oxidation of asphalt has a high effect on its chemical properties and consequently, on the rheological properties that lead to the deterioration of desirable asphalt performance. Oxidation which is the main ageing mechanism which can be verified and quantified by functional group analysis using any image analysis methods. [11]

II. POLYMER MODIFIED BITUMEN

Sengoz et al. [1] conducted a laboratory study on polymer modified bitumen with styrene-butadiene-styrene and ethylene vinyl acetate as copolymers. For improving the characteristics and properties of bitumen, some modifiers are adopted in which polymer modification is of great importance. The polymers derive their strength and elasticity from physical and cross linking of the molecules into a three dimensional network. A fluorescence microscopy is used to determine the state of dispersion of the polymer within the base bitumen. Fluorescent microscopy is based on the principle that polymers swell due to the absorption of some of the constituents of the base bitumen and due to the fluorescence effect in ultraviolet light. The bitumen rich phase appears dark or

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

black, whereas the polymer rich phase appears light. The morphology of the polymer modified bitumen is studied by using a fluorescent microscope and characterized by the nature of the continuous phase and fineness of the dispersion of the discontinuous phase.

Lu et al. [2] studied the effect of ageing on bitumen chemistry and rheology. The deterioration of asphalt pavements is usually enhanced by means of premature ageing of binders. Ageing of binders occurs during the mixing and compaction processes and also during the service conditions in the road. The study conducted by ageing the binders by means of thin film oven test and rolling thin film oven test. The effect of ageing on bitumen chemistry and rheology is investigated using infrared spectroscopy, chromatography and dynamic mechanical analysis. Seven grades of binders are selected and the results of unaged samples are compared with the aged samples which are aged using the two types of ageing methods. The functional characteristics of binders before and after ageing are determined using the infrared spectroscopy. Since bitumen is completely soluble in carbon disulphide, solutions are prepared in carbon disulphide and blank and sample scans are done. In thin layer chromatography, samples are prepared in dichloromethane. The bitumen is separated into four generic fractions, that is, saturates, aromatics, resins and asphaltenes by means of suitable analyser. In gel permeation chromatography, the solutions of binders are prepared in tetrahydrofuran. The dynamic mechanical analysis is done by means of a Rheometer. Oxidation which is the main ageing mechanism which can be verified and quantified by functional group analysis using Infrared spectroscopy. From the study of generic fractions, it is concluded that ageing decreases aromatics and at the same time increases the content of resins and asphaltenes. However, the content of saturates changes slightly due to their inert nature to oxygen.

Wu et al. [3] studied the influence of ageing on the rheology of polymer modified bitumen. The standard rolling thin film oven test and pressure ageing test methods are used to age the specimens in the laboratory. The specimens are aged to assess the role and effect of polymer in bitumen. For characterising the morphology of bitumen, Fourier Transform Infrared spectra are used. The change of chemical structure of bitumen is obtained by the calculation of functional and structural indices of carbonyl, butadiene and sulphoxide groups from FTIR spectra.

Valencia, et al. [4] modelled the performance of asphalt pavement using the response surface methodology. Two types of asphalt are used for the study and the crystallised fractions and the carbonyl groups of both the asphalt samples are determined by differential scanning calorimeter and Fourier Transform Infrared respectively.

Airey [5] evaluated the rheology of polymer modified bitumen by using three types of bitumen from various sources. The morphology, thermal properties and rheological characteristics of the polymer modified bitumen are analysed using fluorescent microscopy, differential scanning calorometry and dynamic mechanical analysis using a dynamic shear rheometer, respectively. The results of the investigation indicated that the polymer modification increases binder stiffness and elasticity at high service temperatures and low loading frequencies. Fluorescent microscopy is used to study the morphology of the polymer modified bitumen by determining the quality and nature of the dispersion of the polymer within the modified binder. Fluorescent microscopy is based on the principle that polymers swell due to absorption of some of the constituents of the base bitumen and, subsequently, fluoresce in ultraviolet light. From the results, it is clear that the fluorescent images show a

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

change in the morphology of the polymer modified bitumen as the polymer content increases. The rheological properties of bitumen are improved by means of the polymer modification.

Airey, et al. [6] studied the rheological properties of both binder and mix which deals with the linearity limits and rheological properties of various asphalt mixtures using unmodified and modified bituminous binders. Polymer modified bitumen are used for the study and the experiments are done by dynamic shear rheometer and the results are then compared with the unmodified bitumen. The study concluded that the linear viscoelastic rheological characteristics of the mixtures are similar with some differences in complex modulus and phase angle but seen at intermediate temperatures and frequencies.

Sengoz, et al. [7] studied the morphology and conducted the image analysis of polymer modified bitumen. The morphology of the polymer modified bitumen samples are characterized and determined by means of fluorescent light optic microscopy and Qwin-Plus image analysis software, respectively. The results indicated that the morphology of the polymer modified bitumen are dependent on the type of polymer and the percentage of polymer in it. At lower polymer contents, the samples show the presence of dispersed polymer particles but at higher polymer contents, a continuous polymer phase is observed.

Liu, et al. [9] studied the rheology and chemistry on the ageing properties of polymer modified bitumen. The virgin polymer modified bitumen is kept for 23 years and its field-aged binder is extracted from the pavement after the 22-year service time. The dynamic shear rheometer is used to characterise viscosity and dynamic response of virgin and aged binders; Gel Permeation Chromatography is adopted to analyse the molecular weight distribution of all binders. Results showed that the field-aged binder had a higher viscosity than the lab-aged binder; and the gel permeation chromatography result showed that the lab ageing produced more asphaltenes than the field ageing.

Menapace, et al. [10] studied the microstructural properties of warm mix asphalt before and after ageing. The binders are analysed before and after long-term ageing with the aid of atomic force microscopy in which surface analysis is done. From the study, it is concluded that microstructure morphology of the virgin and modified binders is only slightly altered because of ageing in the laboratory. The surface analysis showed that the dispersed phase in unaged samples expanded more compared with the aged samples.

III.CONCLUSION

A number of studies are there to evaluate the change in the microstructure of the asphalt binder as a function of ageing. The review shows that there is no particular trend in the microstructure of the binder as far as ageing criteria is concerned. There seems to be a strong correlation between ageing and chemistry of the binder used. So when polymer modified bitumen is used then chemistry is of great importance and more studies should be done in this area to assess the compatibility and interaction between the polymer modified bitumen and the base bitumen.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

REFERENCES

[1] Sengoz, B. and Isikyakar, G., Evaluation of the properties and microstructure of SBS and EVA polymer modified bitumen, Science Direct, Construction and Building Materials 22 (2008) 1897–1905.

[2] Lu, X. and Isacsson, U., Effect of ageing on bitumen chemistry and rheology, Construction and Building Materials 16 Ž2002. 15-22.

[3] Wu, S., Pang, L., Moa, L., Chen, Y. and Zhu, G., Influence of aging on the evolution of structure, morphology and rheology of base and SBS modified bitumen, Construction and Building Materials 23 (2009) 1005–1010.

[4] Valencia, L.E.C., Ramirez, A.M., Guzman, E.A. and Garcia, M.E.C., Modelling of the performance of asphalt pavement using response surface methodology—the kinetics of the aging, Building and Environment 42 (2007) 933–939.

[5] Airey, G.D., Rheological evaluation of ethylene vinyl acetate polymer modified bitumen, Construction and Building Materials 16 (2002) 473–487.

[6] Gordon D. Airey, G.D. and Rahimzadeh, B., Combined bituminous binder and mixture linear rheological properties, Construction and Building Materials 18 (2004) 535–548.

[7] Yildirim, Y., Polymer modified asphalt binders, Construction and Building Materials 21 (2007) 66–72.

[8] Sengoz, B., Topal, A. and Isikyakar, G., Morphology and image analysis of polymer modified bitumen, Construction and Building Materials 23 (2009) 1986–1992.

[9] Liu, G., Nielsen, E., Komacka, J., Greet, L. and Ven, M., Rheological and chemical evaluation on the ageing properties of SBS polymer modified bitumen: From the laboratory to the field, Construction and Building Materials 51 (2014) 244–248.

[10] Menapace, I., Masad, E., Bhasin, A. and Little, D., Microstructural properties of warm mix asphalt before and after laboratory-simulated long-term ageing, Road Materials and Pavement Design, 2015, Vol. 16, No. S1, 2–20.

[11] Das, P.K., Baaja, H., Tighea, S. and Kringos, N., Atomic force microscopy to investigate asphalt binders: a state-of-the-art review, Road Materials and Pavement Design, 2016, Vol. 17, No. 3, 693–718.