Western Research Institute

2012 Publications

Fan, L. T., and Tengyan Zhang, 2012, "Estimation of Energy Dissipation and Cost: The Foundation for Sustainability Assessment in Process Design," *Advances in Process Systems Engineering, Vol.3: Recent Advances in Sustainable Process Design and Optimisation*, Editors: Dominic C. Y. Foo, Mahmoud M., El-Halwagi and Raymond R. Tan, World Scientific, pp. 3-64, 2012.

Fan, L. T., and Tengyan Zhang, 2012, "Life Cycle Assessment (LCA)," *Advances in Process Systems Engineering, Vol.3: Recent Advances in Sustainable Process Design and Optimisation*, Editors: Dominic C. Y. Foo, Mahmoud M., El-Halwagi and Raymond R. Tan, World Scientific, pp.65-78, 2012.

Farrar, M. J., R. W. Grimes, C. Sui, J-P. Planche, S-C. Huang, T. F. Turner, and R. Glaser, 2012, "A New Method for Aging Bitumen in the Laboratory." *European Roads Review*, RGRA, Spring 2012, 20: 39-46.

Abstract. This article describes progress towards development of a new thin film (300 μm) short- and long-term aging test suggested as an alternative to the standard rolling thin film oven (RTFO) and pressure aging vessel (PAV) tests. The new test, referred to as the Simple Aging Test (SAT), can be applied to neat and modified bitumens, and emulsion residues. Before the Strategic Highway Research Program, there was considerable interest in static thin film aging. However, the RTFO test was adopted for short term aging because of the large amount of aged asphalt needed for the Bending Beam Rheometer (BBR) test. Since the adoption of the RTFO, it has been found problematic for aging highly modified binders. In the case of warm mix binders, RTFO testing at lower temperature to simulate a "warm" plant may limit rolling needed to uniformly age the material. Recent development of a 4-mm dia. parallel-plate dynamic shear rheometer (DSR) technique allows DSR tests to -40°C, requires only 25 mg of binder, and can estimate BBR m-value and creep stiffness. By combining this new DSR technique with the SAT, the low and intermediate temperature rheology of short and long-term aged bitumens can be determined. Also, there is sufficient aged material to perform high temperature DSR using 25 mm plates. The SAT eliminates the "rolling" issue for polymer modified and warm mix asphalts. The SAT time and temperature equivalent to reach the same aging as the standard RTFO and PAV are reported for several bitumens.

Farrar, M. J., R. W. Grimes, C. Sui, J-P. Planche, S-C. Huang, T. F. Turner, and R. Glaser, 2012, "Thin Film Oxidative Aging and Low Temperature Performance Grading Using Small Plate Dynamic Shear Rheometry: An Alternative to Standard RTFO, PAV, and BBR." Preprint no. 05EE-467, *Proc.*, 5th Eurasphalt & Eurobitume Congress, Istanbul, June 13-15, 2012.

Abstract. This report describes progress towards development of a new thin film (300 μm) short- and long-term aging test suggested as an alternative to the standard rolling thin film oven (RTFO) and pressure aging vessel (PAV) tests. The new test, referred to as the Simple Aging Test (SAT), can be applied to neat and modified bitumens, and

emulsion residues. Before the Strategic Highway Research Program, there was considerable interest in static thin film aging. However, the RTFO test was adopted for short term aging because of the large amount of aged asphalt needed for the Bending Beam Rheometer (BBR) test. Since the adoption of the RTFO, it has been found problematic for aging highly modified binders. In the case of warm mix binders, RTFO testing at lower temperature to simulate a "warm" plant may limit rolling needed to uniformly age the material. Recent development of a 4-mm dia. parallel-plate dynamic shear rheometer (DSR) technique allows DSR tests to -40°C, requires only 25 mg of binder, and can estimate BBR m-value and creep stiffness. By combining this new DSR technique with the SAT, the low and intermediate temperature rheology of short and long-term aged bitumens can be determined. Also, there is sufficient aged material to perform 25 mm dia. DSR to measure high temperature parameters like G*/sin δ or the new Multiple Stress Creep Recovery test. The SAT eliminates the "rolling" issue for polymer modified and warm mix asphalts. The SAT time and temperature equivalent to reach the same aging as the standard RTFO and PAV are reported for several bitumens.

Glaser, R. R, and J. L. Loveridge, 2012, "Low Temperature Oxidation Kinetics of Asphalt Binders." *Preprints, Div. of Petroleum Chemistry, American Chemical Society*, 57 (1): 9-11.

Abstract. A simple dual mechanism model successfully fits the oxidation of 12 asphalt binders originating from a wide variety of sources. The mechanism proposes fast and slow reaction mechanisms in parallel with free radical interactions between the two reaction pathways. Using only one adjustable parameter, the amount of reactive material available for the fast reaction, the differences in asphalt binder oxidation rates can be explained. The same Arrhenius parameters are used for all 12 binders studied. This result suggests that unmodified asphalt binders oxidize with essentially the same chemical mechanism. Since the Arrhenius parameters apply universally, a simple test may be found to characterize the oxidation kinetics for unmodified binders without doing expense long term oxidation experiments.

Huang, S-C., R. Glaser, and F. Turner, 2012, "Impact of Water on Asphalt Aging-Chemical Aging Kinetic Study." *Transportation Research Record 2293*, 63-72. http://trb.metapress.com/content/m5x85w18662g0824/fulltext.pdf

Pauli, A.T., M.J. Farrar, and P.M. Harnsberger, 2012, "Material Property Testing of Asphalt Binders Related to Thermal Cracking in a Comparative Site Pavement Performance Study." In *7th RILEM International Conference on Cracking in Pavements*, Vol. 1, Mechanisms, Modeling, Testing, Detection, Prevention and Case Histories, A. Scarpas, et al., eds., Springer Netherlands, pp. 233-243. http://link.springer.com/chapter/10.1007%2F978-94-007-4566-7_23#page-1

Schabron, J.F., J.F. Rovani Jr., M.M. Sanderson, J.L. Loveridge, L. Nyadong, A.M. McKenna, A.G.Marshall, 2012, "Waxphaltene Determinator Method for Automated Precipitation and Redissolution of Wax and Asphaltene Components." *Energy & Fuels*, 26 (11), 2256-2268. February 27, 2012. http://pubs.acs.org/doi/pdf/10.1021/ef300184s

Schabron, J.F., R.B. Boysen, E.W. Kalberer, and J.F. Rovani, 2012, "Automated Asphaltene Determinator and Saturates, Aromatics, and Resins Integrated Separation." *Prepr. Pap. Am., Chem. Soc. Div. Energy and Fuels,* 57 (1), 1-3.

Abstract. A novel combination of two modes of separation for asphalt binders and heavy oils has been developed. The initial step is an automated Asphaltene Determinator (AD) solubility separation in which asphaltenes are precipitated within a ground inert polytetrafluoroethylene (PTFE)-packed column. The material which is not precipitated in the first step is separated into saturates, aromatics, and resins (SAR) components by normal-phase adsorption liquid chromatography using solvent and flow switching valves. The activated stationary phase is not deactivated, allowing for repeated separations. In a subsequent step the precipitated asphaltene on the PTFE column are re-dissolved using one or more solvents to provide a solubility distribution profile of the asphaltene material. The result is a combined automated AD / SAR separation to provide an unequalled, comprehensive characterization of the sample.

Schabron, J.F., T.F. Turner, J.L. Loveridge, L. Nyadong, A.M. McKenna, V. Lobodin, R.P. Rodgers, and A.G. Marshall, 2012, "Oxidative Aging and Chemical Changes in an Asphalt Binder." *Prepr. Pap. Am., Chem. Soc. Div. Energy and Fuels,* 57 (2), 65-67.

Abstract. Chemical changes due to oxidative aging were evaluated for eight unmodified asphalt binder materials from the Federal Highway Administration (FHWA) Turner-Fairbank Research Center. A reference binder material, a rolling thin film oxidation (RTFO) reference material, and RTFO / pressure aging vessel (RTFO PAV) material properties were compared with binder extracts from slices taken from representative 6-inch core samples from the FHWA Accelerated Load Facility (ALF) site. The analytical methods utilized include Fourier transform infrared (FTIR) spectroscopy, differential scanning calorimetry (DSC), the WRI Asphaltene Determinator separation, and elemental analysis. In addition, select materials were analyzed by ultrahigh resolution electrospray ionization Fourier transform ion cyclotron resonance mass spectrometry (ESI FT-ICR MS) at the National High Magnetic Field Laboratory (NHMFL) at Florida State University.

Schabron, J.F., L. Nyadong, A.G. Marshall, J.F. Rovani, M.M. Sanderson, J.L. Loveridge, and A.M. McKenna, 2012, "Optimized Waxphaltene Determinator Separation of Waxes in Petroleum Residua," *Prepr. Pap. Am., Chem. Soc. Div. Energy and Fuels,* 57 (1), 4-7.

Abstract. The automated Waxphaltene Determinator separation is an on-column precipitation and re-dissolution separation based on freezing, melting, and solubility. Although high-performance liquid chromatography equipment is used, the separation does not involve chromatography. Waxes and asphaltenes are precipitated from 2 mg sample with methyl ethyl ketone at -24 ºC in an inert ground polytetrafluoroethylene-packed column. The precipitated material is re-dissolved in four steps using a series of three solvents of increasing polarity at different temperatures: heptane at -24 ºC, heptane at 60 ºC, toluene at 30 ºC, and methylene chloride:methanol (98:2 v:v) at 30 ºC. This approach allows the detection of waxy, polar, and pericondensed aromatic components in minutes. Fractions were collected from a waxy residuum by repetitive injections. These were characterized by high temperature gas chromatography, Fourier transform infrared

spectroscopy, and high resolution Fourier transform ion cyclotron resonance mass spectrometry.

Turner, F., and J-P. Planche, 2012, “Advances in Bituminous Binder Characterization—The Way Forward to Better Engineered Binders.” *Routes/Roads*, No. 355, pp. 46-55. http://www.piarc.org/en/order-library/17236-en-Advances%20in%20bituminous%20binder%20characterization%20-%20The%20way%20forward%20to%20better%20engineered%20binders.htm