International Journal of Engineering Management and Life Sciences (IJEMLS)
Volume: 01 Issue: 02 | July-2016 www.ijemls.com

Studies and Research on Effect of Temperature on Viscosity of Fluids: A Review

Sunil Jayant Kulkarni

Chemical Engineering Department, Datta Meghe College of Engineering, Airoli, Navi Mumbai, Maharashtra, India, Pin code: 400708

Abstract

Viscosity of a fluid determines its kinematic behavior. The flowing characteristics of fluid and many other properties such as thermal conductivity are function of viscosity. The heat and momentum transfer also depends on viscosity. The viscosity is affected by temperature and pressure. The fluid has to undergo pressure and temperature changes during the chemical process. The change in rheological behavior needs to be studied for knowing the fluid behavior in different conditions and times. Also power requirement in blending depends on viscosity. The current review summarizes research and studies on effect of temperature on viscosity and rheological behavior.

***Key Words*: Nonlinear, behaviour, incompressible, velocity gradient, shear time, rate.**

INTRODUCTION

The chemical process consists of conversion of raw material into products. The purification of raw material and the final product is important and can be carried out by various unit operations such as extraction, distillation, leaching, crystallization etc. The advanced distillation methods such as extractive, reactive and azeotropic distillation are being used for effective process [1,2,3,4,5]. Membrane processes are being used for downstream processing in modern days[6,7,8]. Hydrotropism also can be employed for specific separation applications [9]. Chromatography is used for analysis and separation [10].The fluid properties determines ease of the operation. Handling of liquids in many operations in food, beverage, petroleum, oil and grease industry depends on viscosity behavior.

The fluids are classified as Newtonians and Non Newtonians. The Newtonian fluids obey Newton's law of viscosity. It states that shear stress is proportional to velocity gradient and assumes linear behavior of shear stress and velocity gradient. Other fluids are termed as Non Newtonians and follows power law. In this law the shear stress is proportional to power of velocity gradient. Other than these two there are many other behaviors observed in fluid properties with respect to shear stress and velocity gradient. The viscosity is ratio of shear stress to velocity gradient. The viscosity is very important property of fluids, mainly in petroleum industry, food industry, pharmaceutical industry, pigment industry etc. When one deals with thick fluid or non Newtonian flow, fluid properties such as viscosity and density becomes important. The viscosity is a function of temperature and pressure. Viscosity affects heat and momentum transfer. Also in many cases viscosity is time dependent. It is necessary to study rheological behavior of such fluids along with temperature and pressure dependence. Current review summarizes research on effect of temperature on viscosity and rheological behavior.

EFFECT OF TEMPERATURE AND PRESSURE ON VISCOSITY AND RHEOLOGICAL BEHAVIOR

Xie et.al. carried out investigation on rheological properties of starch [11]. They studied rheological properties of corn starches with different amylose/amylopectin ratios. They characterized the shear stress and melt viscosity characteristics of sample pellets. They observed shear thinning behavior under all conditions, with the power law index ($0< n < 1$). Keshvadi et.al. carried out an investigation on the effect of high temperature on viscosity of palm oil during the ripening process of fresh fruits[12].They used The soxhlet extraction tubes with hexane for palm oil extraction. They observed a non-linear decrease in viscosity with increasing temperature for oil samples. Wang et.al. studied an incompressible fully developed laminar flow in a helical rectangular duct having finite pitch and curvature with temperature-dependent viscosity under heating condition[13]. They found that, the effects of viscosity variation on the flow resistance and heat transfer are more significant for four heated walls. They observed that, the secondary flow enhanced markedly when the temperature-dependent viscosity was considered. El-hefian and

Yahaya carried out an investigation on effects of temperature, shearing time and rate of shear on the viscosity of chitosan/agar-blend solutions[14]. They prepared a number of aqueous solutions of chitosan/agar blends (with chitosan as the major component). For the blend solutions, they investigated the effects of temperature, shear rate and shearing time on the rheological property, i.e. the apparent viscosity. They observed that a non-Newtonian behavior was pronounced at temperatures from 20^{o}C to 50^{o}C for all solutions. Also there was a decrease in viscosity with increasing temperature. At a low shear rate only for pure chitosan solution, shearing time independence was observed.

Nur et.al. carried out laboratory studies on effect of high temperature additive to rheology properties of drilling mud under dynamic conditions[15].They found that increasing temperature will result in decreasing the viscosity (rheology). Abdou developed a numerical model to study the effect of thermal radiation on unsteady boundary layer flow [16]. He investigated temperature dependence of viscosity and thermal conductivity due to a stretching sheet in porous media. Aworanti et.al. carried out an investigation on the effect of temperature on densities and viscosities of binary and ternary blends of soybean oil, soy biodiesel and petroleum diesel oil[17]. They measured viscosities and densities of the binary and ternary blends at different temperatures (20°C to 90°C). In their investigation, they observed that viscosities of binary and ternary blends decreased nonlinearly with temperature, while their densities decreased linearly with temperature. Viscosity-temperature relationships were studied at 1atm in the system diopside-anorthite by Sacarfe[18]. He measured viscosities both above the liquids and in the supercooled liquid region. He observed that viscosities were independent of shear rate, indicating Newtonian viscous behavior or the melts. He also observed decrease in viscosities with temperature. The viscosity depends on amounts of diopside component in the mixtures at constant temperature.

Khomenko and Lyashenko investigated the melting of an ultrathin lubricant film under friction between atomically flat surfaces at temperature for dependencies of viscosity [19]. It was observed that when temperature exceeds critical temperature, the melting of lubricant and, as a result, the sliding mode of friction sets in. In the recent studies, Larsen found that the response of swimming velocity to a change in viscosity is different when subjected to change in temperature or, at constant temperature [20]. The viscosity can be manipulated by addition of a high-molecular-weight polymer (polyvinyl pyrrolidone, PVP) to the ambient seawater. Babcock studied factors affecting viscosity of cream[21]. Effect of butterfat and temperature were two important parameters. Also age was prominent factor. With age, viscosity increases. According to many investigations, viscosity decreases with temperature.

Costa carried out an investigation on nonlinear phenomena in fluids with temperature-dependent viscosity [22]. In conduit when magma flow flows, its viscosity increases because of heat loss. Choudhury et.al. carried out an investigation on fuel properties like viscosity of ten biodiesels namely soybean oil methyl ester(SMEA, SMEB,GMSME), yellow grease methyl ester(YGME), Corn (COME), Sunflower (SFME), Safflower (SOME), Walnut (WOME), Linseed (LOME)[23]. The main objective of his investigation was to analyze effect of temperature and unsaturation of fame (fatty acid methyl ester) on viscosity prediction for biodiesel. They observed that the degree of unsaturation affects viscosity of the system.Kimilu et.al. carried out an investigation on properties and rheological behavior of jatropha methyl ester[24]. The sustainability of fuel for its use depends on key factors like the specific gravity and viscosity. The aim of their study was to investigate the effects of temperature and blending on specific gravity and viscosity of Jatropha methyl ester. They concluded that blends with up to 50% JME conformed to both specific gravity and viscosity without the need of preheating.Topallar and Bayrak carried out an investigation on the effect of acetone on the dynamic viscosity of sunflower-seed oil[25]. They observed dramatic decrease in viscosity because of acetone. They also observed a linear relation between the density of sunflower-seed oil and temperature.

Esteban et.al. carried out investigation on temperature dependence of density and viscosity of vegetable oils[26]. According to them, physical parameters of vegetable oil can reach values very close to that of diesel fuel by adequately heating the vegetable oil before entering the injection system. It is possible to improve their combustion performance by properly controlling temperature. Rafe and Masood investigated steady shear rheological properties of Cordia abyssinica gum, as a novel hydrocolloid at 30 to 50 degree Celsius[27]. They found that the apparent viscosity was drastically affected by temperature. Herschel-Bulkley model best fitted experimental data. They also observed a weak thixotropic behavior particularly at low shear rates. According to them, this substance has a high potential for application in food and neutaceutical products as it possess yield stress and pseudoplastic behavior. Romero and Beltran, in their investigation studied the effect of temperature on the viscosities of aqueous solutions of 3-aminopropanoic acid, 4-aminobutanoic acid, 5-aminopentanoic acid and 6-aminohexanoic acid as a function of concentration [28]. They observed that the concentration dependence of the viscosity of aqueous solutions of α,ω-amino acids exhibits the usual behavior. It was also found that solution viscosity increased with amino acid concentration. A polynomial second order equation described the effect of temperature on the viscosity of the solutes in aqueous solution.

CONCLUSIONS

The effect of temperature on viscosity of starch, palm oil, chitosan/agar-blend solutions, soybean oil, soy biodiesel and petroleum diesel oil, methyl ester(YGME), Corn (COME), Sunflower (SFME), Safflower (SOME), Walnut (WOME), Linseed (LOME) has been investigated by various investigators. These studies have indicated that the viscosity decreases with temperature. The temperature – viscosity behavior was different for different fluid/liquid. In case of binary and ternary blends of soybean oil, soy biodiesel and petroleum diesel oil. Viscosities of binary and ternary blends decreased nonlinearly with temperature, while their densities decreased linearly with temperature. Viscosities were independent of shear rate, indicating Newtonian viscous behavior or the melts for the system diopside-anorthite. The sustainability of fuel for its use depends on key factors like the specific gravity and viscosity. Proper blending can bring about desirable change in viscosity.

REFERENCES

[1] Kulkarni SJ (2015), Molecular Distillation: A Review on Applications and Affecting Parameters. Int J Res. 2(1):310-15.

[2] Kulkarni SJ (2014). Solar Distillation: A Review",Int. J Res. 1(11):1171-76.

[3] Kulkarni SJ (2015). Review on Research and Advancements in Extractive Distillation. Int J Res. 2(1):306-9.

[4] Varga V, Rev E, Gerbaud V et al. (2006), Batch Extractive Distillation with Light Entrained. Chem Biochem Eng Q. 20(1):1-23.

[5] Bhatt RP, Thakore SB (2012). Extractive Distillation of Acetic Acid from its Dilute Solution using Lithium Bromide, Int J Sci Eng Tech. 1(2):46-50.

[6] Kulkarni SJ (2014). Use of Biotechnology For Synthesis Of Various Products From Different Feedstocks -A Review. Int J Adv Res Bio-Tech. 2(2): 1-3.

[7] Silva FSA, Benachour M, Abreu CAM (2015). Evaluating Hydrogen Production In Biogas Reforming In A Membrane Reactor, Brazilian J Chem Eng. 32(1):201-10.

[8] Triwahyon S, Jalil AA, Nu H et al. (2006). Development of Membrane Reactor for Epoxidation of Propylene To Propylene Oxide In A Single Step Process. Inst Eng Malaysia. 67(3):7-12.

[9] Kulkarni SJ, Goswami AK (2014). Research on Application of Hydrotropy:A Review. Int. J Sci Eng Tech Res.3(10):2617-19.

[10] Kulkarni SJ, Goswami AK, Shinde NL (2015). A Review on Use of Chromatography for Analytical Applications, Int J Sc Res Sci Eng Tech.1(4):83-85.

[11] Xie F, Yu L, Su B et al. (2009). Rheological properties of starches with different amylose/amylopectin ratios. J Cereal Sci. 49:371–77.

[12] Keshvadi A, Endan JB, Harun H et al. (2011). The Effect of High Temperature on Viscosity of Palm Oil During the Ripening Process of Fresh Fruits, Int J Sci & Eng Res. 26:1-7.

[13] Wang C, Liu S, Wu J et al. (2014). Effects Of Temperature-Dependent Viscosity On Fluid Flow And Heat Transfer In A Helical Rectangular Duct With A Finite Pitch, Brazilian J Chem Eng. 31(3):787–97.

[14] El-hefian EA, Yahay AH (2010). Effects of temperature, shearing time and rate of shear on the viscosity of chitosan/agar-blend solutions, Maejo. Int J Sci Technol. 4(2):261-67.

[15] Nur S, Dody N, Rejeki HS (2005). Laboratory Study of High Temperature Additive to Rheology Properties of Drilling Mud under Dynamic Conditions, Proceedings World Geothermal Congress, Antalya, Turkey, 24-29 April 2005:1-7.

[16] Abdou MMM (2010), Effect of Radiation with Temperature Dependent Viscosity and Thermal Conductivity on Unsteady a Stretching Sheet Through Porous Media, Nonlinear Analysis: Model Control. 15(3):257–70.

[17] Aworanti OA, Agarry SE, Ajani AO (2012). A Laboratory Study of the Effect of Temperature on Densities and Viscosities of Binary and Ternary Blends of Soybean Oil, Soy Biodiesel and Petroleum Diesel Oil. Adva Chem Eng Sci. 2: 444-52.

[18] Scarfe CM (1983). Viscosity-temperature relationships at I atm in the system diopside-anorthite, Amer Mineralo. 6E:1083-88
[19] A.V.Khomenko,I.A.Lyashenko(2006),Temperature Dependence Effect of Viscosity on Ultrathin Lubricant Film Melting. Condensed Matter Physics. 9(4): 695–702
[20] Larsen PS, Madsen CV, Riisgård HU (2008). Effect of Temperature and Viscosity on Swimming Velocity of the Copepod Acartia tonsa, Brine Shrimp Artemia salina and Rotifer Brachionus plicatilis. Aquat Biol. 4: 47–54
[21] Babcock CJ (1931). Some Factors Affecting The Viscosity Of Cream, Technical Bulletin No. 249, United States Department of Agriculture, Washington, DC.1:18
[22] Costa A (2002). Nonlinear Phenomena in Fluids with Temperature-dependent Viscosity: An Hysteresis Model for Magma Flow in Conduits, Geophy Res Lett. 29(10):41-44
[23] Choudhury S, Mitra S, Bose PK (2015). Effect of Temperature and Unsaturation of Fame (Fatty Acid Methyl Ester) on Viscosity Prediction for Biodiesel. Int J Emerg Tech Adv Eng. 5(10):174-79
[24] Kimilu RK, Nyangaya JA, Onyari JM (2011). The Effects of Temperature and Blending on the Specific Gravity and Viscosity of Jatropha Methyl Ester. ARPN J Eng App Sci. 6(12):97-106
[25] Topallar H, Bayrak Y (1998). The Effect of Temperature on the Dynamic Viscosity of Acetone Sunflower-Seed Oil Mixtures. Turk J Chem.22:361-66
[26] Esteban B, Riba JR, Baquero G et al. (2012). Temperature dependence of density and viscosity of vegetable oils. Biom Bioener. 42:164-71
[27] Rafe A, Masood HS (2014). The Rheological Modeling and Effect of Temperature on Steady Shear FlowBehavior of Cordia abyssinica Gum. J Food Process Technol, 5(3):1-5
[28] Romero CM, Beltran A (2012). Effect of Temperature and Concentration on the Viscosity Of Aqueous Solutions of 3-Aminopropanoic Acid, 4-Aminobutanoic Acid, 5-Aminopentanoic Acid, 6-Aminohexanoic Acid. Rev Colomb Quím. 41(1): 123-31.