ISSN 2181-8622

Manufacturing technology problems

Scientific and Technical Journal Namangan Institute of Engineering and Technology

INDEX COPERNICUS INTERNATIONAL

Google Scholar

Crossref doi

SLIB.UZ Scientific library of Uzbekistan

Volume 9
Issue 2
2024

STUDY OF RHEOLOGICAL FLOW CURVES OF ED20 EMULSIONS

OCHILOV AKBARJON

Doctoral student of Namangan Institute of Engineering and Technology, Namangan, Uzbekistan
Phone: (0894) 279-6997, E-mail: ochilovakbarjon95@gmail.com
Corresponding author.

URINBOEVA MARIFATOY

Doctoral student of Namangan Institute of Engineering and Technology, Namangan, Uzbekistan
Phone: (0894) 279-6997, E-mail: ochilovakbarjon95@gmail.com

ABDIKAMALOVA AZIZA

Chief Researcher at the Institute of General and Inorganic Chemistry of the Academy of Sciences of the Republic of Uzbekistan, Tashkent, Uzbekistan

KULDASHEVA SHAKHNOZA

Professor of the Institute of General and Inorganic Chemistry of the Academy of Sciences of the Republic of Uzbekistan, Tashkent, Uzbekistan

ESHMETOV IZZAT

Professor of the Institute of General and Inorganic Chemistry of the Academy of Sciences of the Republic of Uzbekistan, Tashkent, Uzbekistan

Abstract: The article discusses the main properties of ED20 emulsions - its rheological characteristics and determines the shear stress at different shear rates, the strengthening effect on the structure of the emulsion.

Methods. To establish the rheological properties and characteristics of resinous substances and their curing processes, viscometric studies were carried out using the Reotest-2.1 device. To do this, the composition under study was placed in a wedge-shaped slot between a stationary plate and a cone, the width of which has a diameter d. The process was carried out at different temperatures and the values of the parameter α were calculated.

Results. Rheological studies of epoxy resin emulsions with different concentrations of LABSA (linear alkylbenzenesulfonic acid) show that these systems have structured non-Newtonian properties. At all analyzed levels of epoxy resin, an increase in the proportion of emulsifier leads to an increase in rheological parameters such as ultimate shear stress, viscosity and others.

Conclusion. The rheological characteristics of ED20 emulsions demonstrate non-Newtonian behavior, characterized by a decrease in viscosity with increasing shear rate. This effect is especially pronounced when using PEG and LABSA as emulsifiers, which emphasizes their importance in stabilizing emulsion systems and the need for careful selection of surfactants depending on the target properties of the finished products.

Keywords: Emulsion-ED20, epoxy oligomers, viscometer, Reotest-2.1., liquid, rheological curves, linear alkylbenzenesulfonic acid, polyethylene glycol.

Introduction. In the world, among various types of aqueous disperse systems, emulsions or dispersions (liquid/liquid) of epoxy oligomers, both in the field of fundamental research and in solving applied problems, occupy one of the leading places. Therefore, the widespread use of emulsion technologies in many industries also determines the need for further, more in-depth study of the physical and chemical processes in these disperse systems, aimed at improving the quality and consumer properties of the final product[15-16].

In recent decades, aqueous dispersions of polymers, especially epoxy oligomers, have attracted increasing attention from researchers and industrialists. This is due to their wide range of potential applications in various industries such as paints, construction, electronics and many others. Research in this area is of particular relevance in light of the constant desire to develop new materials and technologies with improved properties and higher environmental safety. However, despite significant achievements in the field of synthesis and application of aqueous dispersions of epoxy oligomers, questions remain open regarding their structure, properties and production methods [2,3-5,12-14].

The relevance of this study on the rheological flow curves of ED20 epoxy resin emulsions is closely related to practical applications in the field of coatings for oil and gas industry pipes. Epoxy resins are known for their outstanding adhesive properties, chemical and mechanical resistance, making them an ideal material for protective coatings in the extreme operating conditions found in the oil and gas industry [1-3,9-11].

Understanding the rheological behavior of such emulsions allows their formulations to be optimized to achieve desired coating properties, including improved distribution, penetration and adhesion to pipe surfaces. This directly affects the durability and reliability of the protective layer, reducing the likelihood of corrosion, wear and damage caused by external factors [3-8].

Methods and materials. To establish the rheological properties and characteristics of resinous substances and their curing processes, viscometric studies were carried out using the Reotest-2.1 device. To do this, the composition under study was placed in a wedge-shaped slot between a stationary plate and a cone, the width of which has a diameter d. The process was carried out at different temperatures and the parameter values were calculated α. Based on the data obtained, the value of dynamic shear stress was calculated (τ):

$$\tau = \alpha * c, \quad (1.1)$$

where, c – cone constant; α – indication on the indicator device, divisions;

Using dynamic shear stress data, dynamic viscosity values were calculated (Па·с):

$$\eta = \frac{\tau}{D}, \quad (1.2)$$

where, D – shear rate 1/c.

Determination of conditional viscosity was carried out using a V3-4 viscometer in accordance with GOST 8420-74.

Results. Rheological studies of epoxy resin emulsions with different concentrations of LABSA (linear alkylbenzenesulfonic acid) show that these systems have structured non-Newtonian properties. At all analyzed levels of epoxy resin, an increase in the proportion of emulsifier leads to an increase in rheological parameters such as ultimate shear stress, viscosity and others.

Rheological flow curves are a graphical representation that demonstrates the relationship between shear stress and shear rate (velocity gradient) for a material. These curves are a key tool in rheology for characterizing the behavior of liquids and soft solids under deformation and flow. In Fig. 3.5 shows flow curves for ED20 emulsions with different resin contents and various surfactants.

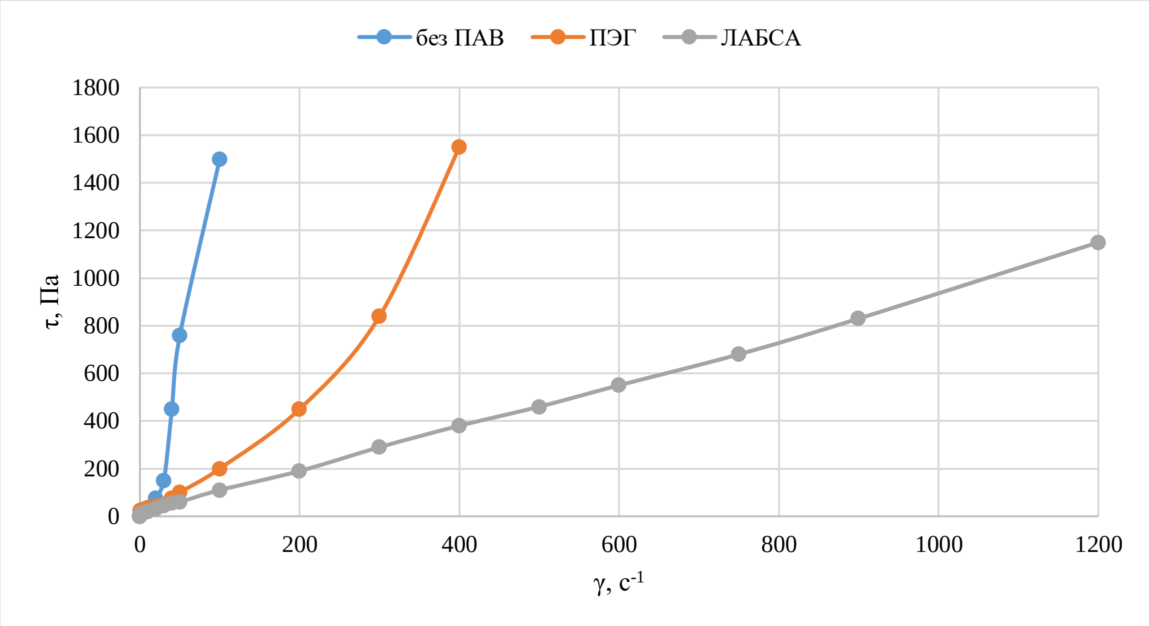

Figure 1. Rheological flow curves of ED20 emulsions (40% ED20. 3% Surfactant).

In Figure 1 demonstrates the relationship between shear stress and shear rate for water-epoxy systems with varying levels of the emulsifiers LABSA and DEAOA (diethanolamide of oleic acid). From the data, for the same epoxy and emulsifier content, it can be seen that as the shear rate increases, the shear stress increases, which shows the expected relationship for non-Newtonian fluids. The shear stress values increase from 15 Pa at a shear rate of 1 c^{-1} to 1500 Pa at 100 c^{-1}. This increase is approximately linear, indicating a moderate change in viscosity with increasing shear rate.

Discussion. The introduction of PEG (polyethylene glycol) as a surfactant leads to an increase in shear stress at the same shear rates compared to an emulsion without a surfactant. Starting from 25 Pa at a shear rate of 1 c^{-1}, the stress reaches 840 Pa at 300 c^{-1} and continues to increase at a higher rate, reaching 1550 Pa at 400 c^{-1}.

Emulsions with LABSA show lower shear stress values compared to PEG at each shear rate level. This may indicate that LABSA reduces emulsion viscosity to a greater extent than PEG. Shear stress starts at 10 Pa at a shear rate of 1 c^{-1} and increases to 1150 Pa at 1200 c^{-1}.

At all shear rates, the shear stress values for emulsions with PEG are higher than those with LABSA. This indicates that PEG provides higher viscosity and therefore potentially higher structural stability of the emulsion compared to LABSA.

Based on these data, it can be concluded that the type of surfactant significantly affects the rheological properties of epoxy resin emulsions, which must be taken into account when selecting surfactants for specific applications, including pipe coatings in the oil and gas industry, where certain rheological characteristics are required to ensure quality application and durability of the coating.

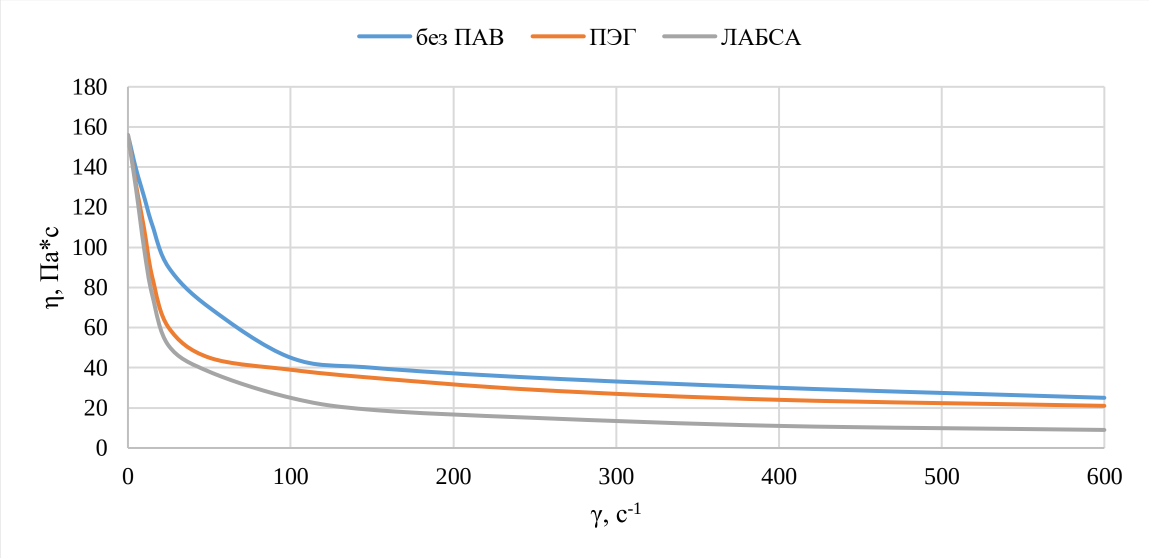

Figure 1. Dependence of viscosity on shear rate.

From the graph and data provided, it is clear that the dependence of viscosity on shear rate for various epoxy resin emulsions with and without added surfactants (PEG and LABSA) follows the general pattern of a non-Newtonian fluid, where viscosity decreases with increasing shear rate.

The curve for the surfactant-free emulsion shows a moderate decrease in viscosity with increasing shear rate. This indicates pseudoplastic behavior typical of many polymer systems.

In the presence of PEG, the rate of viscosity decrease with increasing shear rate is higher than that of the emulsion without surfactants.

This may indicate more pronounced pseudoplastic properties of the PEG emulsion, which may be associated with increased polymer-polymer interactions or microstructural changes in the emulsion.

The curve for the LABSA emulsion shows the fastest decrease in viscosity with increasing shear rate, indicating the highest level of pseudoplasticity among the three samples studied. The sharper decrease in viscosity may result from the formation of smaller and more mobile LABSA micelles in the emulsion.

The practical significance of such data lies in the possibility of optimizing emulsion compositions for specific technological processes. For emulsions used as pipe coatings in the oil and gas industry, it is important to ensure sufficient fluidity for ease of application and at the same time sufficient viscosity after application to create a reliable protective layer. Thus, controlling rheological properties can improve the application characteristics and durability of coatings.

A study of the rheological properties of ED20 epoxy resin emulsions revealed their non-Newtonian behavior and showed a significant influence of added surfactants on these properties. Rheological flow curves confirmed the pseudoplastic nature of the emulsions, with a decrease in viscosity with increasing shear rate. This is especially true for emulsions with the addition of PEG and LABSA, where it has been observed that PEG increases viscosity more than LABSA, which may help improve the structural stability of the emulsion.

Such data is of great practical importance because it allows the optimization of emulsion compositions to ensure optimal conditions for application and subsequent operation of coatings, especially in such a critical area as coatings for oil and gas pipes. Ensuring sufficient fluidity for application and appropriate viscosity after application will improve the quality and extend the service life of protective coatings, which in turn will increase the safety of oil and gas transportation and reduce environmental risks.

Conclusion. The rheological characteristics of ED20 emulsions demonstrate non-Newtonian behavior, characterized by a decrease in viscosity with increasing shear rate. This effect is especially pronounced when using PEG and LABSA as emulsifiers, which emphasizes their importance in stabilizing emulsion systems and the need for careful selection of surfactants depending on the target properties of the finished products. PEG as an emulsifier promotes higher shear stress values at different shear rates compared to LABSA, indicating its stronger strengthening effect on the emulsion structure.

Thus, these studies not only contribute to the development of scientific knowledge in the field of materials science and polymer chemistry, but also have important practical implications for improving the efficiency and performance of pipe coatings, which are critical to safety and economic efficiency in the oil and gas industry.

References

1. Попов И.Г., Георгиев Н.П. Реологические свойства резистивных паст // Электронная техника. Сер. 6. Материалы. 1980. Вып. 5 (142). С. 109–111.

2. Диниссен, А. М. Водные эпоксидные связующие системы / А. М. Диниссен, Ю. В. Ташкинова // Лакокрасочные материалы и их применение – 2008. –№ 1-2. – С. 58-62.

3. Пакен, А. М. Эпоксидные соединения и эпоксидные смолы / Под ред. Л. С. Эфроса Пер. с нем. – Л.: Госхимиздат, 1962. – 964 с

4. Lee, H. Handbook of Epoxy Resins / H. Lee, K. Neville. – New York: McGraw-Hill., 1982, 922 p.

5. Виноградов Г.В., Малкин А.Я. Реология полимеров. М., 1977. 440 с

6. Амирова, Л. М. Модификация эпоксидных связующих для армированных стекло- и базальтопластиков/Л. М. Амирова, Р. Х. Сайфутдинов, А. Ф. Магсумова, Р. Р. Амиров // Журнал прикладной химии. – 2001. – Т. 74, Вып. 11. – С. 1881–1884.

7. Амирова, Л. М Эпоксидные лакокрасочные материалы для расслаивающихся покрытий/Л. М. Амирова, К. А. Андрианова, А. Ф. Магсумова // Лакокрасочные материалы и их применение. – 2003. – № 5. – С. 3–6.

8. Н.И. Полежаева, А.Ю. Радзюк, В.А. Бабкин, В.А. Левданский Исследование реологических свойств концентрированных растворов полиэфирной смолы, модифицированной канифолью. Химия растительного сырья. 2010. №1. С.

171–175

9. Бородавкин П.П. Подземные магистральные трубопроводы. Москва: Недра; 1998. 84 с. Borodavkin P.P. Underground main pipelines. Moscow: Nedra; 1998. (In Russ.).

10. Кутуков С.Е. Информационно-аналитические системы магистральных трубо проводов. Москва: СИП РИА; 2002. 324 с. Kutukov S.E. Underground main pipelines. Moscow: Nedra; 1998. (In Russ.)

11. Коршак А.А., Махмотов Е.С. Магистральные трубопроводы. Уфа: ДизайнПоли графСервис; 2008. 448 с. Korshak A.A., Makhмотов E.S. Main pipeline. Ufa: Dizajn Poligraf Servis; 2008. (In Russ.).

12. R.W. Revie, Uhlig's corrosion handbook, John Wiley & Sons, 2011

13. M. Mobin, Hina Shabnam Corrosion Behavior of Mild Steel and SS 304L in Presence of Dissolved Copper. **Journal of Minerals and Materials Characterization and Engineering**, Vol.9, No.12, 2010. Pp 1113-1130.

14. D.S. Chauhan, V.S. Saji, Heterocyclic Organic Corrosion Inhibitors: Principles and Applications, Elsevier, 2020. P. 298

15. V.S. Sastri, Corrosion inhibitors: Principles and applications, John Wiley & Sons, 1998.

16. V.S. Sastri, Green corrosion inhibitors: Theory and practice, John Wiley & Sons, 2012.

17. Waterbased Acrylates for Decorative Coatings – Technical book Series: European Coatings Literature. Author: Manfred Schwartz, Roland Baumstark. published April 2001. 284 p.

18. Казакова, Е.Е. Водно-дисперсионные акриловые лакокрасочные материалы строительного назначения / Е.Е. Казакова, О.Н. Скороходова / М.: изд-во ООО «Пэйнт-Медиа». – 136 с

19. Щукин, Е. Д. Коллоидная химия / Е. Д. Щукин, А. В. Перцов, Е. А. Амелина. – М.: Высшая школа, 2004. – 445 с.

20. Бабак, В. Г. Высококонцентрированные эмульсии. Физико-химические принципы получения и устойчивость. – М.: Успехи химии 77 (8). – 2008. – с. 729 – 730.

CONTENTS