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Research of Foaming Characteristics of DEA and MEA

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ABSTRACT. The article covers the results of research to determine the effect of organic and inorganic substances on the foaming capacity of alkanolamines. The influence of various organic additives like paraffinic, naphthenic hydrocarbons, condensate fraction and alcohols, and inorganic additives like $MgCO_3$, $CaCO_3$, KCl, K_2SO_4 on the foaming ability of a 25% DEA solution and a MEA solution has been determined. Based on the obtained results of experimental studies, alignment charts have been plotted.

KEYWORDS: alkanolamine, diethanolamine, airing, foam height, foam life, hydrocarbons, hydrophobic, alcohol, hydrophilic, inorganic salts, pattern.

I. INTRODUCTION

Lately, production of natural gas and gas condensate in Uzbekistan has been intensively increasing. At the gas processing plants of Republic, for the purification of natural gas from acidic components, the absorption purification method using various amine solutions, such as monoethanolamine (MEA), diethanolamine (DEA) and methyldiethanolamine (MDEA) is widely used. It should be considered that these alkanolamines are not produced in the Republic. According to data from Uzbekneftegaz JSC, 312 tons of DEA and 3.522 tons of MDEA have been imported for natural gas purification in 2018, in the value of 1.780 USD and 1.950 USD per ton, respectively.

Using amine solutions in gas purification processes has a number of disadvantages, the main of which is the foaming of the absorbent, and in some cases, a decrease in its absorption capacity over time [1]. Foaming leads to disruption in the operation of equipment, deterioration in the quality of the purified gas and, as a result, to the need to reduce the productivity of the sorption system, therefore, during foaming, the loss of expensive amines increases because of entrainment with gas [2].

Causes of foaming can be the following [3]: increase of temperature mode in the system; entry of various inhibitors used in gas production to the equipment; decomposition of amines under the influence of high temperatures; accumulation of products of the hydration process in amine solutions; ingress of gummed hydrocarbons into the absorber in the form of drops; presence of mineralized water dispersions in the composition of the gas at the inlet to the absorber; entry into the system of acidic components.

In this regard, studying each of these factors requires finding the most appropriate methods and developments for issuing recommendations to control foaming in the natural gas purification system. Often these recommendations come down to control the consequences of foaming, and not its cause.

Taking into account the above mentioned, the purpose of this work is to study the effect of various substances on the foaming capacity of alkanolamines.

II. METHODS

Objects and methods of research. The objects of research were standards of paraffinic, naphthenic hydrocarbons, condensate fractions and alcohols, as well as MEA, DEA alkanolamines.

Foaming capacity of alkanolamines has been determined according to the technical condition method approved by "Mubarek Gas Processing Plant" LLC.

Testing of absorbents and antifoams, evaluation of effect of various impurities (hydrocarbons, corrosion inhibitors, etc.) on absorbents has been carried out in "large" bubbler, composed of cylinder with a capacity of 1000 cm^3 and HFP (hexafluoropropylene) type filter placed in it. Diagrams of installations for determining the foaming capacity of alkanolamine solutions are given in Fig. 1 and 2.

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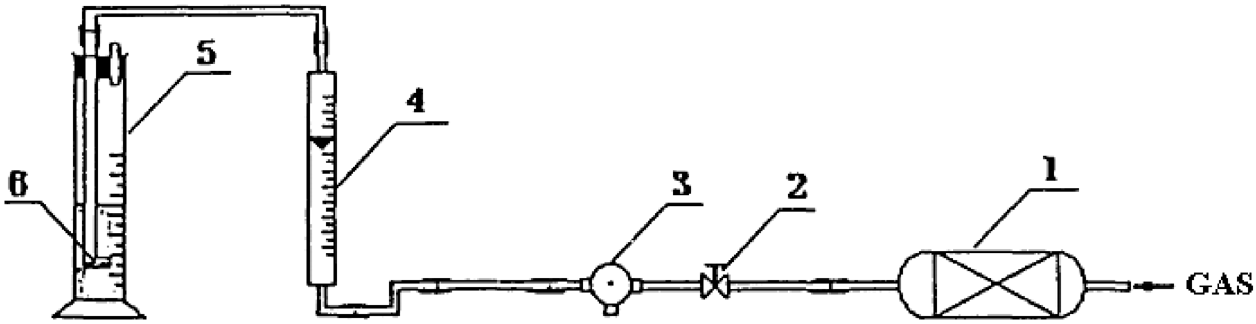

Fig. 1. Installation for determining the foaming capacity of alkanolamine solutions: *1* – filter for air drying; *2* – airflow regulator; *3* – three-way valve; *4* – rotameter (rheometer); *5* – cylinder; *6* – filter-air disperser

During control of the technological process of gas purification, as well as insufficient amount of test solution, a “small” bubbler, with a volume of 100–150 cm^3, made by welding a glass tube of the same diameter, 250–260 mm long, to the WF (water filter) (Fig. 2) is recommended.

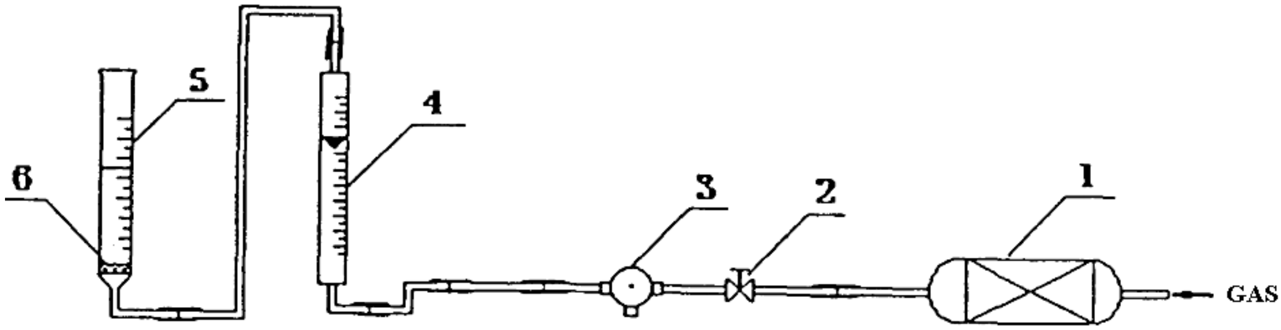

Fig. 2. Installation for determining the foaming capacity of alkanolamine solutions: *1* – filter for air drying; *2* – airflow regulator; *3* – three-way valve; *4* – rotameter (rheometer); *5* – bubbler; *6* – filter-air disperser

III. RESULT

Results of research. In order to conduct experiments to determine the effect of organic substances on the foaming of alkanolamines, the following reagents were chosen: 25% (wt.) used solution of DEA as solution of alkanolamine, and pentane, octane, nonane, undecane, cyclopentane, cyclohexane, 120°C and 150°C fractions of condensate, methanol, 10% residue from the distillation of technical methanol, as well as pure DEA solution as organic substances. During the experiment, the height (*H*) of the foam of a 25% DEA solution with the addition of the above organic substances to it at different concentrations has been determined. The results obtained are shown in the table.

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Table
The results of determining the foam height of 25% DEA solution with various additives

No.	Sample names	Mass fraction of additives, %	Foam height *H*, mm
1.	DEA + pentane	0.1 0.5 1.0	0 0 3
2.	DEA + octane	0.1 0.5 1.0	1 4 11
3.	DEA + nonane	0.1 0.5 1.0	8 22 24
4.	DEA + undecane	0.1 0.5 1.0	21 32 37
5.	DEA + cyclopentane	0.1 0.5 1.0	1 3 0
6.	DEA + cyclohexane	0.1 0.5 1.0	- 0 5
7.	DEA + 120°C fraction condensate	0.1 0.5 1.0	4 8 11
8.	DEA + 150°C fraction condensate	0.1 0.5 1.0	8 12 17
9.	DEA + methanol	0.1 0.5 1.0	0 0 0
10.	DEA + residue (10%) from the distillation of technical methanol	0.1 0.5 1.0	0 1 3
11.	DEA + pure DEA solution	0.1 0.5 1.0	0 0 0

Based on results of research presented in the table, a graph of the dependence of the foam height (*H*) of a 25% DEA solution on the mass fraction of various additives is plotted (Fig. 3).

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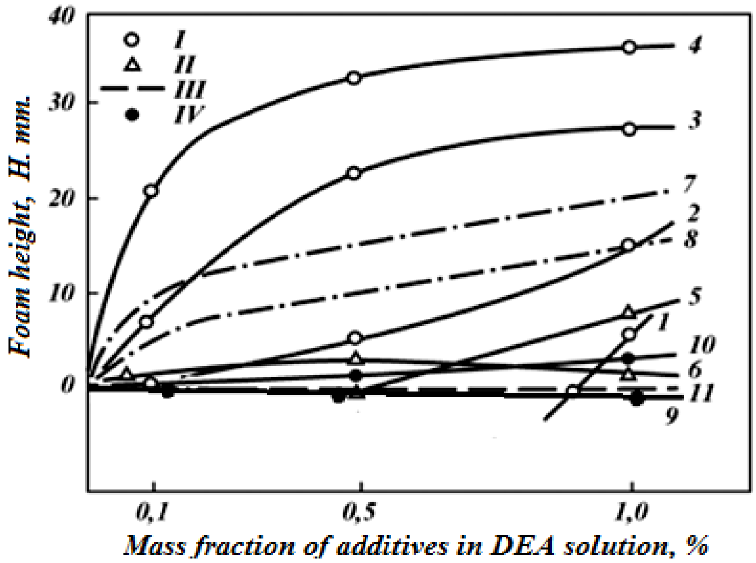

Fig. 3. Influence of various additives on the foaming capacity of 25% DEA solution:
I – paraffins; *II* – naphthenes; *III* – condensate fractions; *IV* – alcohols; *1* – C_5H_{12}; *2* – C_8H_{18}; *3* – C_9H_{20}; *4* – $C_{11}H_{24}$; *5* – C_6H_{12}; *6* – C_5H_{10}; *7* – condensate, fraction 150°C; *8* – condensate, fraction 120°C; *9* – methanol; *10* – residue (10%) from the distillation of technical methanol; *11* – pure DEA solution.

IV. DISCUSSION

Obtained results of research showed that the foam ratio depends on nature and properties of impurities in the gas coming from the field and can cause foaming of amine solutions. The greatest foaming is caused by hydrocarbons having start of boiling above 100°C (condensate, oil), surfactants, and some corrosion inhibitors. From the results of the experiment, it has been determined that hydrophobic substances, such as paraffinic, naphthenic, aromatic hydrocarbons and condensate fractions, increase the height and life of the foam, while hydrophilic substances, such as alcohols and amino alcohols, reduce them or do not form foaming of the solution.

In order to determine the effect of inorganic substances on the foaming ability of alkanolamines, the following salts: $MgCO_3$, $CaCO_3$, KCl, K_2SO_4 and MEA solution have been chosen. Results of experimental research to determine the effect of salts $MgCO_3$, $CaCO_3$, KCl, K_2SO_4 on the foaming of the MEA solution are shown in Fig.4.

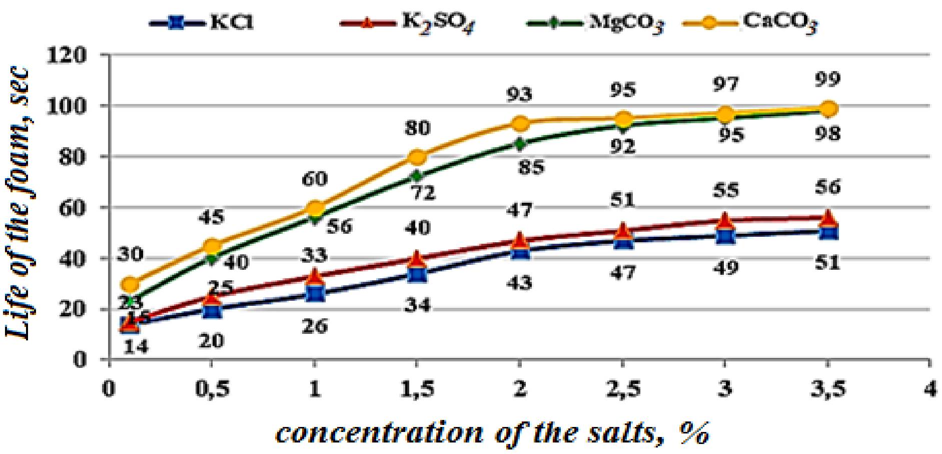

Fig. 4. Dependence of the duration of life of the foam τ (sec) on concentration of salts C (%) in MEA solution

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This graph shows that the concentration of inorganic salts also affects the foaming capacity of amine solutions, that is, with increase in the concentration of salts, the duration of life of the foam of amine solutions also increases.

V. CONCLUSION

According to the results of experimental research, regularity of the influence of organic and inorganic substances on foaming capacity of alkanolamines has been established, since hydrophobic substances such as paraffin, naphthenic, aromatic hydrocarbons and fractions of hydrocarbon condensates increase the ratio and life of the foam, meanwhile additives with a hydrophilic property, like alcohols and amino alcohols, reduce the ratio and life of the foam or do not form foaming of the solution, and inorganic salts stabilize the foam properties with an increase in its life.

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