WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979, Volume 4, Issue 12, December, 2023

SYNTHESIS AND TESTING OF SOLUTIONS OF A COMPOSITE ABSORBENT BASED ON NITROGEN- AND AMINE-CONTAINING WATER-SOLUBLE POLYELECTROLYTE IN THE PURIFICATION OF NATURAL GAS FROM SULFUR-CONTAINING COMPONENTS

Aripdjanov Oybek Yusupdjanovich,
Kholmatov Shokhrukh Furqat ugli,
Kayumov Jamshid Sayfullayevich
Tashkent Institute of Chemical Technology
E-mail: aripdjanov81@gmail.com

Abstract

Natural, organomineral, synthetic and composite sorbents are used to clean oil and gas from sour gases, the production of which is increasing year after year. Approximately 55% of which are used to purify natural and industrial gases from sulfur-containing organic compounds, mercaptans, carbonyl sulfide, carbon disulfide and other sulfur-containing compounds. At the same time, special attention is paid to the production of a new composite universal generation of these sorbents and technologies for their extraction and use.

The purpose of this study is to improve the technology of purification of natural and secondary gases from sulfur compounds using composite absorbents.

The objectives of the study were to create a composition and technology for modifying diethanolamine and methyldiethanolamine with nitrogen- and amino acid water-soluble polyelectrolytes to purify gases from acidic components, as well as to study the effect of newly created composite absorbents on the absorption and desorption of H2S and CO2 in gas.

The synthesis of nitrogen- and amine-containing water-soluble polyelectrolyte (NWSP) based on formalin, diethanolamine (DEA) and monodiethanolamine (MDEA) was found that the composition of the reaction products of DEA and MDEA with formalin substantially depends on the synthesis temperature. It can also be assumed that the composition of the reaction products is influenced by the presence or absence of a solvent. In order to identify effective indicators compared to the working absorption (18-20%) monodiethanolamine solution used on the amine unit directly during gas cleaning and absorbent regeneration, an active MDEA solution was used with the addition of the calculated amount of nitrogen-containing water-soluble polyelectrolytes MDEA+NWSP =20% + 5.0% and determined the absorption capacity, the rate of announcement, viscosity, specific all, foaming, the content of H2S in the purified gas, amine number and other physical and chemical indicators.

Test results can be generally concluded that adding composite NWSP solutions to MDEA working solutions allows improving the technological characteristics of the absorption gas cleaning process.

Keywords: adsorption, absorption, nitrogen-containing water-soluble polyelectrolytes, absorption, monodiethanolamine, amine plant, viscosity, specific gravity, foaming, sulfur.

Introduction

The world production of natural, organomineral, synthetic and composite sorbents used to refine oil and gases from acid gases, has doubled against the past decade. Oil and gas processing enterprises use 55 per cent of the sorbents to purify natural and exhaust gases from acidic components of mercaptans, carbonyl sulfides, carbon disulfide and other sulfur-containing compounds. In addition, special attention is paid to building a generation of new universal composite sorbents, and production and development of these sorbents application technology [1].

The synthesis of new nanostructured composite sorbents used for the complete utilization of various wastes of oil and gas processing enterprises, the improvement of the technology for the purification of natural and tail exhaust gases from acid impurities, the increase in the stability of the physicochemical properties of sorbents, and the improvement of environmental conditions for the processing of secondary sorbents of oil and gas processing enterprises is an urgent task of today.

Based on this, ongoing research work is aimed at improving the physicochemical properties of sorbents. In addition, there are no studies in the literature on the thermochemical stability of composite absorbents based on nitrogen-containing water-soluble polyelectrolytes (NWSP). This is primarily due to the fact that absorbents of this type have not yet found wide distribution abroad [2–4].

Materials and Methods

The aim of the work is to create a technology for obtaining new composite absorbents to protect the environment.

The objectives of the study are to modify the composition of diethanolamine and methyldiethanolamine with nitrogen- and amino acid water-soluble polyelectrolytes for gas purification from acidic components, followed by studying the effect of the created composite absorbents on the absorption and desorption of H_2S and CO_2 in gas.

WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979, Volume 4, Issue 12, December, 2023

The composite absorbent was tested at the Mubarek Gas Processing Plant (MGPP) (Uzbekistan, Kashkadary region, Mubarek city) using nitrogen-containing water-soluble polyelectrolytes (NWSP) as an absorbent in gas purification. In order to identify effective indicators in comparison with the working absorption (18-20%) solution of MDEA used in the amine plant directly in gas purification and regeneration of absorbent, a working MDEA solution was used with addition of a calculated quantity of nitrogen-containing water-soluble polyelectrolytes - MDEA+NWSP=20%+5.0% and absorption capacity, absorption factor, viscosity, specific total, foaming, H2S content in the purified gas, amine number, and other physical and chemical parameters were determined.

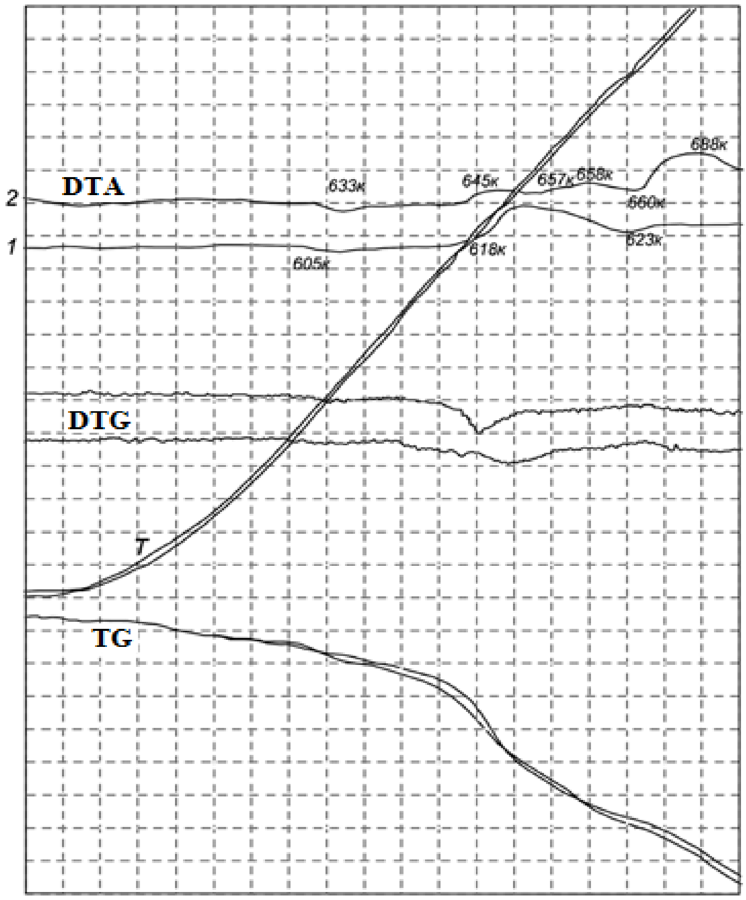


Fig. 1. Thermogram of water-soluble polyelectrolytes
1. FEAP-1. 2. FEAP - 2. Source: [Aripdjanov O. et al, 2021].

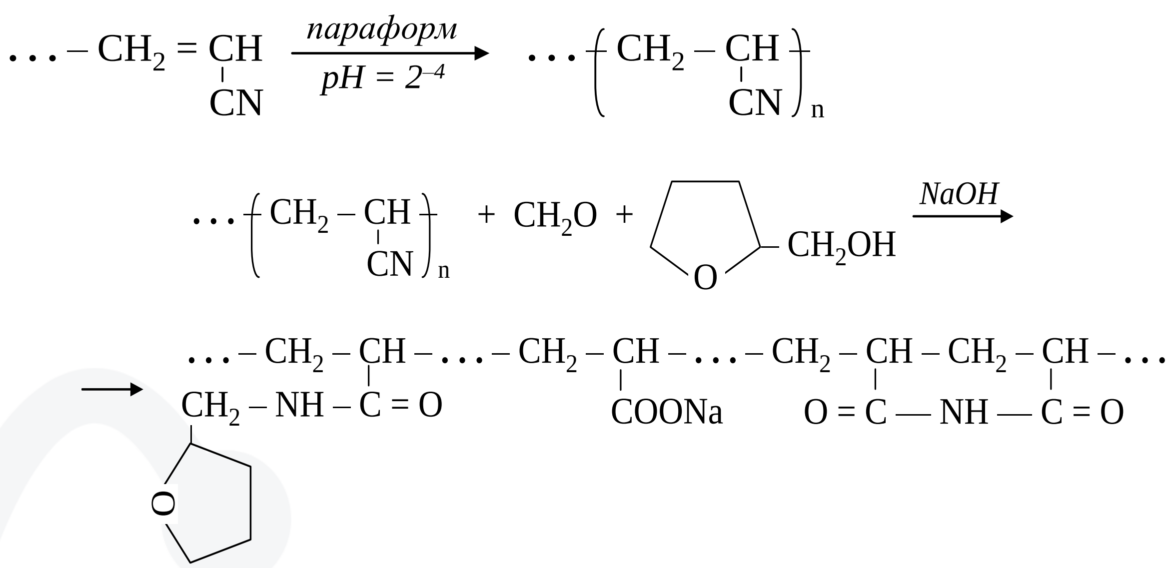
Physicochemical properties of solutions were characterized by values of electrical conductivity measured by the generally accepted method and potentiometric titration.

Surface tension (G) of NWSP solutions was determined by method of the highest bubble pressure on Rehbinder device. Polymerization process takes 1.5-2 hours at the temperature range of 338-343K. This forms a white suspension with large

WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979, Volume 4, Issue 12, December, 2023

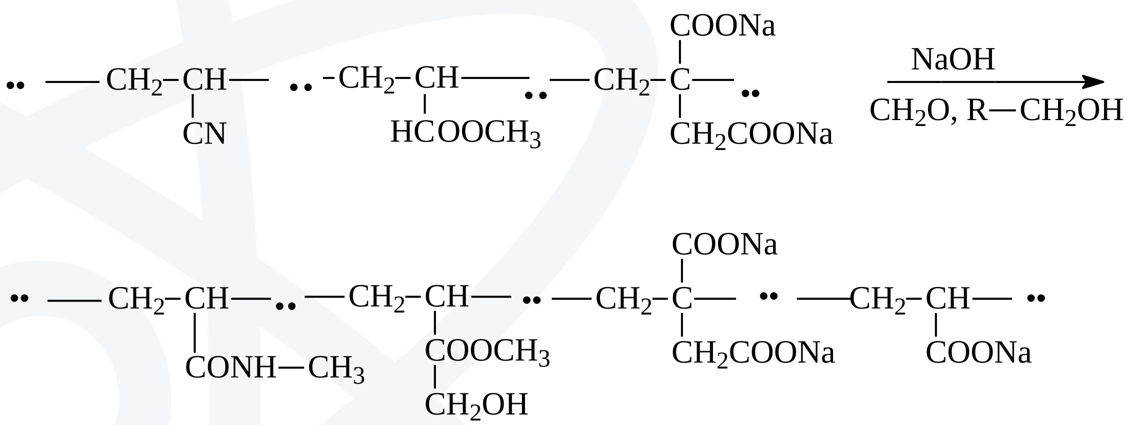
polymer particles. Then, in the presence of formalin and VAT residue of furfuryl alcohol, the saponification process was carried out. In this case, the formed amide groups interact with furan compounds through formaldehyde, and the product obtained by this method is conventionally designated as FEAP-1 and FEAP-2.

Method of FEAP-1 water-soluble polyelectrolyte production.



where: $R=C_4H_4O$

Method of FEAP-2 water-soluble polyelectrolyte production.



where: $R=C_4H_4O$

To study the composition and characteristics of the obtained polyelectrolytes "FEAP-I" and "FEAP-2", some physico-chemical methods of analysis were applied. Table 1 shows the chemical composition of nitrogen and amine-containing water-soluble polyelectrolytes.

ISSN: 2776-0979, Volume 4, Issue 12, December, 2023

Results

According to the results of the synthesis of NWSP, DEA and MDEA based on formalin, it was found that the composition of the products of the interaction of DEA and MDEA with formalin to a greater extent depends on the synthesis temperature. It can also be assumed that the presence or absence of a solvent, in our case, this is water, affects the composition of the reaction products.

The IR spectra of FEAP polyelectrolytes produced based on Nitron fiber production waste and still residues of tetrahydrofurfuryl alcohol (THFA) showed a shift in the region of 1670–1700 cm–1 and 1300–1450 cm–1 due to
C–CH2-R shift (where R-THFA) and hydrogen bonding.

Absorption band in the region of 1220 cm-1, which is a characteristic of CH2 groups, and a wide absorption band in the region of 3000-3600 cm-1, which is common to -COOH- group and hydroxyl, increases due to binding of -CH2-R, formation of bridges through formalin. There is also a new broad absorption band in the region of 1110-1300 cm-1, which is specific for alcohol hydroxyls
(-CH2OH) and carboxyls (-COOH).

Table 1.
Chemical composition and some other characteristics of nitrogen and amine-containing water-soluble polyelectrolytes

No.	Polymer name	Element content, %					Conten, mg		Acid number, mg KOH	Viscosity of 1% solution
		Carbon	Hydrogen	Nitrogen	Sulfur	Oxygen	Na2O	CO2		
1.	FEAP-1	41.15	4.12	7.85	-	42.95	7.15	5.35	466	20-30
2.	FEAP-2	47.65	3.65	2.70	-	33.45	13.27	5.12	495	12-25

Source: [Aripdjanov O. et al, 2021].

Onset temperature of active decomposition of the WSP in question goes up by 473-523 K. Before processing polyelectrolytes, an increase in temperature leads to noticeable changes and due to alternating links of macromolecules of the FEAP series of NWSP containing various hydrophilic groups - intermolecular interactions. A subsequent increase in temperature can lead to the destruction of the main chains of macromolecules (C-C). According to the data of permogravimetric analysis (DTA), the WSP of the FEAP series can be attributed to thermostable polyelectrolytes (Fig. 1).

The influence of important physicochemical and colloidal-chemical parameters of synthesized new composite absorbents using NWSP on the degree of purification of natural gas from sulfur-containing components has been studied, produced a composite MDEA-based absorbent with addition of a calculated amount of NWSP MDEA + NWSP = 20% + 5.0% and determined absorption capacity, absorption index, viscosity, specific gravity, foaming, H2S content, amine number and other physicochemical and colloidal - chemical parameters.

The test results are shown in Table 2.

Table 2. Comparative indicators of the tested absorption NWSP solutions

Indicators of absorption solutions	Agent working solution of MDEA 25 ÷ 35% wt.	Recommended compositions of working solutions MDEA (20) + NWSP (5) %
Specific watering, l/m^3	1.1 ÷ 1.2	0.9 ÷ 1.1
Absorption rate, n_D^{20}	1.4995	1.4970
Solution pH	9.8	10.2
Absorption capacity, mol/mol	0.42 ÷ 0.45	0.55-0.65
Viscosity, η cPs	4.85	4.61
Foaming, (h) cm.	2.5	1.5 ÷ 1.64
H2S content in purified gas, g/m^3	0.022	0.014
Amine number	22.5	23.8
Absorption temperature, °C	35 ÷ 45	35 ÷ 40
Desorption temperature, °C	123 ÷ 127	115 ÷ 125
Characteristics of purified gas by content: H_2S, mg/m^3 CO_2, %	12 ÷ 15 2.0	6 ÷ 9.0 1.35

Source: [Compiled by the authors].

The data given in table-1 prove that the use of composite absorption solutions in the purification of natural gas from acidic components with the absorbent MDEA+NWSP leads to an improvement in their operational technological properties. At the same time, the quality of gas purification from acidic components remains within the normal range; -H2S in m3-7 mg, -CO2 in m3-0.51 g.

Discussion

The authors of works [5-10] address the problems of purification of natural and exhaust gases from acid components of mercaptans, carbonyl sulfides, carbon disulfide and other sulfur-containing compounds. Also, special attention is paid to the creation of a generation of new universal composite sorbents and their application. But despite the foregoing, there are no studies in the literature on the thermochemical stability of composite absorbents based on nitrogen-containing water-soluble polyelectrolytes, which was the purpose of this study.

Conclusion

The study studied the effect of the main physicochemical and colloidal-chemical parameters of synthesized new composite absorbents using NWSP on the degree of purification of natural gas from sulfur-containing components. The resulting composite absorbent based on MDEA with the addition of the calculated amount of NWSP MDEA+NVRP = 20% + 5.0% and determine the absorption capacity, absorption index, viscosity, specific gravity, foaming, hydrogen sulfide content, amine number and other physicochemical and colloidal chemical parameters. The test results confirm that the use of composite absorption solutions in the purification of natural gas from acidic components with the absorbent MDEA+NWSP shows an improvement in their operational technological properties.

Based on the obtained results of the tests, it can be generally concluded that adding NWSP composite solutions to MDEA working solutions improves technological characteristics of gas absorption purification process and have a significant impact on the improvement of the environment.

References

1. Aripdjanov O., Tirkasheva X. Increasing and intensification of the technology of purification of natural gas by composite absorbents // E3S Web of Conferences Volume 25820 May 2021 Article number 120082021 Ural Environmental Science Forum on Sustainable Development of Industrial Region, UESF 2021.
2. Lunin A.F., Husejn A., Burdejnaya T.N. Utilizaciya serovodoroda iz kislyh gazov aminovoj ochistki. // Himiya i tekhnologiya topliv i masel. -2001. №12 – pg.13.
3. Hall P.D. Corrosion innibition in alkanolamine acid gas removal Plants // Doklad na prezentacii kompanii «Dow Chemical» Moscow-1980. Pgs. 24-26.
4. Gerasimenko M.N., Bryukhov A.V., Isaev A.V. Orenburg Gazprom. Problemy and perspective processing of natural gas and OGZ. // Gazovaya promyshlennost. -2001. - №6. - p. 29-31.
5. Fang-yuan Jou, Alan E. Mather, Fr D. Otto / Solubility of H2S and CO2 by Methyldiethanolamine Solutions // Ind. Eng. Chem. Process Des. 1982.- v.21. -p. 539-544.

WEB OF SCIENTIST: INTERNATIONAL SCIENTIFIC RESEARCH JOURNAL
ISSN: 2776-0979, Volume 4, Issue 12, December, 2023

6. Alekseev S.Z., Afanasev A.I., Kislenko N.N., Korenev K.D. / Purification of natural gas alkanolamine ot serovodroda, carbon dioxide and drugix primesey // -M.: OOO IRTs GAZPROM, 1999. - p. 41.
7. British Petroleum Statistical Review of World Energy, 2002.
8. Lavrentev I.A., Alexandrov V.M. Degradation of ethanolamines in absorption gas purification. Sposoby regeneration. Osobennosti vosstanovlennix MEA, DEA i MDEA. //ZAO Khimtek Injiniring". http://sintez-oka.com/upload/pdfs/publication11.pdf
9. Tetelmin V.V., Yazev V.A. Zashchita okrujayushchey sredy v neftegazovom complex // Dolgoprudny: Izdatelsky dom "Intellect". 2009. p. 352
10. T.B. Turaev., Sh.Sh. Mengliev., N.A. Igamkulova., Kh.N. Rakhimov., J.T. Olimov., B.N. Kenjaev. Development of technology for purifying natural gas from sulfur compounds based on physico-chemical properties // Uzbekistan oil and gas. Scientific and technical magazine. - Tashkent, 2019, No. 3. p. 30-32.