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ХІМІЧНІ, ФІЗИЧНІ ТА МАТЕМАТИЧНІ МЕТОДИ ДОСЛІДЖЕННЯ ПРОЦЕСІВ ТА АПАРАТІВ

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of minus 65 ... minus 100 °C. Such cooling gas temperature can be achieved when using an external refrigeration cycle (cascade propane-ethane cycle) or combined cooling cycle (propane cold and use of turbo-expander). During the processing of oil and natural gas in the gas processing plant for deep extraction of ethane, propane and heavier hydrocarbons most widely used five different technological schemes of LTC (Table 1).

Table 1

Type of the LTC scheme	Extraction rate, %		
	C_1+C_2	C_{3+}	C_{4+}
With propane and internal refrigeration cycles	40	90	97
With the turbo-expander	40-60	90	96
With a cascade refrigeration cycle	60-80	95	99
With the propane refrigeration cycle and turbo-expander	60-80	95	99
With a cascade of propane and ethane refrigeration cycle and turbo-expander	60-85	95	99

During the processing of petroleum gases technological schemes in which an external propane refrigeration cycle coupled with the internal one are primarily used. In the first stage of gas cooling to a temperature of minus 30 °C an external propane refrigeration cycle is used and on the second stage for lower temperatures achieving – throttling of liquid flow, obtained in the process, or expansion of partially stripped gas in turbo-expander. Depending on the desired product the technological scheme of LTC for hydrocarbons of C_{2+} or C_{3+} is applied.

Analysis of technical and economic performance of the LTA installation and the installation of the LTC with a turbo-expander shows that at the same output of propane and heavier hydrocarbons capital and operating costs when using the LTC installation with a turbo-expander are lower. Besides, the hardware execution of technological scheme of the LTA is bulky (the number of machines is almost 2 times greater).

Studies have shown that gas processing schemes of low-temperature absorption maintaining the same level of extraction of target components in a depleted natural gas requires an increase in consumption of the absorbent, more power, additional heat input, on what hardware and equipment are not calculated. The use of expander hub in the LTC schemes makes the whole process easily controlled, since the process parameters like self-correcting and maintained at the desired level, providing the required level of target components extraction. It is the great advantage of the LTC schemes with a turbo-expander hub. The use of mixed refrigerant allows getting the temperature for the evaporation of light components much lower than the evaporation isotherm of propane, and thereby achieving a better extraction rate of target components. And the parameters of refrigeration cycle are selected in such way that after compression in refrigeration machines and after cooling by reverse flow of dry gas refrigerant is fully condensed.

Scientific Supervisor – DSc, Professor M.G.Khmelniuk

STUDY OF NONLINEAR DIELECTRIC PROPERTIES OF P(VDF-TFE) COPOLYMER FILM

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To study the dielectric nonlinearity of P(VDF-TFE)copolymer films of 30 μm thickness we performed six series of experiments on unpolarized and polarized, unannealed

and annealed films both in the heating and the cooling modes. Electrification of the samples was performed at a temperature of 20 °C and a voltage of 3 kV for 10 minutes. Preliminary, Al electrodes of 180 mm^2 area were deposited on both surfaces of the film. Annealing of the films consisted of aging for one day at 120 °C. All measurements were performed at a frequency of 1 kHz in the temperature range from 20 to 150 °C.

In the unpolarized specimens, we selected only the first and the third harmonics, while in the polarized films – the first, the second and the third harmonics. In all cases, we found real and imaginary parts of the dielectric constant of the first, the second and the third order.

Comparison of the obtained data has shown that ε'_1 was almost not affected by temperature, and ε'_1 in polarized films was smaller than in unpolarized (8-9 and 11-12). On the graphs of $P_r\gamma$ dependence on temperature one can see two relaxation processes with peaks at 50 °C and 125 °C. The first process is probably caused by the space-charge events, while the second one can be attributed to the approximation of the ferro-paraelectric transition, although the characteristic sharp increase of ε'_1 in this zone was not observed. It is possible that this transition was strongly blurred , so that the characteristic Curie temperature was close to or even above the melting temperature of the crystallites.

It was found that annealing only slightly changes the form of the $\varepsilon'_1(T)$ dependence, so that there is a weak peak at 135 °C. Upon cooling, ε'_1 of heated and annealed films remains equal to 14, regardless of temperature. Quasi-stationary state is quickly established after the electrification. After 4 hours of exposure ε'_2 decreased from $2{,}6\cdot10^{-9}$ m/V to $2{,}1\cdot10^{-9}$ m/V.

Temperature dependence of ε'_1 and ε'_3 in polarized films when heated was somewhat different from non-polarized films. The value of ε'_1 slightly but monotonically increased from 16 at 20 °C to 28 at 140 °C, while ε'_3 at 120 °C decreased dramatically changing the sign. At the same temperature, ε'_2 has also changed the sign.

Values of $P_r\gamma$ in annealed films were smaller than in non-annealed, and the temperature dependence was practically the same, except that P_r decreased to zero in the annealed films at 130 °C, and in unannealed films at 135 °C.

Upon cooling, ε'_1 and ε''_1 of the heated and annealed polarized films repeated the curves during heating, and the graph of ε'_3 noted a slight temperature hysteresis. The most strong is the difference of ε'_2 during heating and cooling. When the sample is heated, ε'_2 gradually decreases from $3\cdot10^{-9}$ m/V to zero at 130 °C and $\varepsilon'_2 = 0$ during the cooling in a wide temperature range from 110 °C to 120 °C.

It is clear from the presented results that the expected ferroelectric-paraelectric transition was not clearly seen. The most likely reason is that the characteristic transition temperature was above the melting temperature of the crystalline phase. The same feature was observed in pure PVDF homopolymer. In the copolymers with TFE relationship between the Curie point and the melting point is probably dependent on the content of TFE.

Scientific supervisor – DSc, (Physics & Mathematics), Professor A.E.Sergeeva,

METHOD OF NONLINEAR DIELECTRIC MEASUREMENTS IN FERROELECTRIC POLYMERS

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Dielectric properties of ferroelectric polymers depend on both crystalline and amorphous phases. Measurements of dielectric nonlinearity, i.e. the expansion coefficients of

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