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LATEST ACHIEVEMENTS IN THE SYNTHESIS OF POLYMERIC REAGENTS [illegible] [1]

by

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United Nations Industrial Development Organization

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[illegible]

[illegible]

1. At present [illegible] engin[illegible] [illegible] development [illegible]

The production [illegible] electr[illegible]

2. [illegible]

3. The [illegible] high [illegible]

[illegible] required [illegible] different [illegible] relatively small [illegible]

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[illegible]

The production of [illegible] by [illegible] depends [illegible] of petrochemical raw materials ([illegible], [illegible], [illegible]).

The degree of [illegible] [illegible] [illegible].

5. It is [illegible] relatively [illegible].

[illegible]

6. The [illegible]

7. The [illegible] in various fields of technique.

1ᴇ4))

[illegible]

Ion exchange received [illegible] like [illegible]
[illegible] electri[illegible]
[illegible] forms. [illegible]
[illegible] water from water
[illegible] water [illegible]
[illegible].

[illegible] water being [illegible]
[illegible]. [illegible]
[illegible] the [illegible] all for the per-
[illegible] which
[illegible] under [illegible]
[illegible]. [illegible]
[illegible] properties [illegible].

[illegible] properties [illegible]
[illegible] exchange between [illegible]
[illegible].
[illegible] water [illegible] applied [illegible]
[illegible].

[illegible] natural
[illegible] water [illegible]. [illegible]
[illegible]
[illegible]) limited the possi-
[illegible], [illegible] efforts were
[illegible] the manufacture [illegible] exchangers through sulfonation
[illegible]. [illegible]; its manufacture
[illegible]. [illegible] manufac-
[illegible] the introduction of
[illegible] ion exchangers
[illegible] impor-
[illegible]. [illegible]
[illegible] with such

higher [illegible]

[illegible] include [illegible]

[illegible] Late [illegible]

[illegible]

a) [illegible] of self [illegible]

b) [illegible]

c) [illegible]

d) [illegible]

[illegible] of the [illegible] established [illegible]

[illegible] (1942) [illegible] of [illegible] exchanger [illegible] silica.

[illegible] exchangers through [illegible] industrial [illegible].

[illegible] divi[illegible] [illegible] brought [illegible] exchangers with g[illegible] [illegible] number of [illegible]. Th[illegible] [illegible] in [illegible] [illegible] for [illegible]. [illegible] obtained through the [illegible].

[illegible] exchangers were [illegible] water, exchanger of [illegible] in 19[illegible]. [illegible] produced in [illegible] [illegible] specific [illegible], the [illegible] exchangers produced [illegible] exch[illegible] [illegible].

[illegible] observed [illegible] selectivity [illegible] but [illegible] been achieved [illegible] organic compounds, including drying substances. [illegible] pretreatment [illegible] de[illegible] ion exchangers [illegible] and juices.

All [illegible] [illegible] thus, economically profit[illegible] [illegible] can be carried on wi[illegible] [illegible] materials and pre[illegible] whi[illegible] [illegible] of salt [illegible] well. [illegible] during [illegible] (current [illegible] current [illegible] energy consumption. [illegible] membranes [illegible] efficiency [illegible] waters with [illegible].

[illegible] manufacture [illegible] large size [illegible] consider [illegible] is reduced, ion exchange [illegible] point of view [illegible] of residual salt content), [illegible] efficiency. Successful [illegible] lization [illegible] it possible to widen [illegible] up to very high concentrations.

In the U[illegible] [illegible] work [illegible] and purification [illegible] ion exchange [illegible] with [illegible] [illegible] wa[illegible] eliminated, and, [illegible] synthesizing [illegible].

[illegible]

[illegible] exchange [illegible], [illegible] (1, 2) [illegible] electr[illegible] [illegible] the following [illegible]

-1- [illegible] exchanger [illegible]

[illegible]-2- [illegible] divinyl [illegible]

[illegible]-2-2 [illegible] with [illegible] content of divinyl[illegible]

[illegible]-2- [illegible] -2- [illegible] purified [illegible].

[illegible] exchanger [illegible]

[illegible] acid.

[illegible] acid.

[illegible] - 1, [illegible] - 1 - [illegible] exchanger on the basis of [illegible].

[illegible]

[illegible] - 1 - Low basic anion exchanger on the basis of condensation product [illegible] formaldehyde.

[illegible] - 2 - Low basic anion exchanger [illegible] polyethylenepolyamine, phenol and formaldehyde.

[illegible] - Low basic anion exchanger [illegible] on the basis of [illegible] formaldehyde.

[illegible] -31- - Low basic anion exchanger [illegible] polycondensation type.

-10 - Medium basic anion exchanger [illegible] polycondensation type.

[illegible] - Polycondensation type anion exchanger on the basis of pyridine, [illegible] epichlorohydrin

[illegible] - 1[illegible] - Strongly basic anion exchanger [illegible] polymerization type on the basis of [illegible].

[illegible] - [illegible].

[illegible] amounts of [illegible] still being manufactured. [illegible] softening of industrial water. [illegible] the so-called [illegible].

[illegible] low [illegible] strength [illegible] the [illegible] large [illegible].

[illegible] composition and structure [illegible] their chemical [illegible] properties [illegible] pressure, including [illegible], microbes, colloids, [illegible] substances contained in [illegible].

[illegible] ngc

[illegible] result of development [illegible] exchangers and ion [illegible] chemical technology finding [illegible] and technology. [illegible] application.

Fields of application [illegible]

[illegible]	[illegible]	[illegible]	[illegible]
1.	[illegible] softening	[illegible]	[illegible]

[illegible] / [illegible]

	[illegible]	[illegible] used	Degree of implementation
[illegible].	Deionisation	[illegible] KU-2, [illegible] -1 [illegible] [illegible] -2, [illegible] -31, [illegible] -22, [illegible] -1	Universal industrial application
[illegible].	Demineralization	[illegible] -17	Universal industrial application
[illegible].	[illegible] of high degree pure water	[illegible] ion exchanger [illegible] -1 [illegible] (....) [illegible] filter	Wide industrial application
[illegible].	[illegible] of highly [illegible] water	[illegible] - [illegible], [illegible] - 2	Industrial application
[illegible].	[illegible] water	[illegible] -1.	Industrial
[illegible].	[illegible] from [illegible]	[illegible] -1, [illegible] -1	- " -
[illegible].	[illegible] water	[illegible] - [illegible], [illegible] - [illegible]	
[illegible].	[illegible] of juice	[illegible] -1, [illegible] -1.	Industrial application
[illegible].	Demineralization of sugar [illegible]	[illegible] exchangers. [illegible] ion exchanger	
[illegible].	Decolorizing of sugar [illegible]	[illegible] -1 [illegible], [illegible] -1 -1	Industrial application
[illegible].	[illegible]	[illegible] -1, [illegible] exchanger -1	- " -
[illegible].	[illegible]	[illegible] exchangers. [illegible] -2-	- " -

No	Proce[illegible]	[illegible] used	[illegible]
14.	[illegible] from solution [illegible] leaching [illegible]	[illegible] wo[illegible] used	[illegible]
15.	G[illegible] from solutions	[illegible]-1, [illegible]-1[illegible], [illegible]-[illegible]	Industrial
16.	Copper extraction from the liquid [illegible] viscose [illegible]	Strongl[illegible] exchangers [illegible]	- " -
17.	[illegible] from platinum, [illegible] and iridium with [illegible] exchanger [illegible]	Strongl[illegible] [illegible]	[illegible]
18.	[illegible]	Strongl[illegible] acid cation exchangers [illegible]-2	Industrial
19.	Concentration of nickel, copper, silver and [illegible] waste	Anion exchanger [illegible]-31 [illegible] exchangers [illegible]-1, [illegible]-2.	- " -
20.	Removal of radioactive substances from liquid	Anion exchangers [illegible]-2 cation exchangers [illegible]-1, [illegible]-1	- " -
21.	Nickel and cobalt pick-up from the liquid effluents of nickel production	Cation exchangers [illegible]-1, [illegible]-2	Semi-industrial
22.	Extraction of chromium after chrom[illegible]	Anion exchangers [illegible]-17, [illegible] cation exchangers [illegible]-2-2	
23.	Extraction of silver from the wastes of photographic and motion picture industry	Cation exchangers	Industrial
24.	Extraction and purification of streptomycin	[illegible] cation exchangers [illegible]-2, [illegible]-1	- " -
25.	Extraction and purification of other antibiotics	Various	- " -
26.	Extraction and purification of vitamins	- " -	- " -

No.	Process	Materials used	Degree of introduction
[illegible]	Purification of [illegible]	Strongly acidic cation exchanger [illegible]	Industrial
[illegible]	Purification of [illegible] acid	Strongly acidic cation exchanger [illegible]-1, low-basic anion exchanger [illegible]	- " -
[illegible]	Formation of [illegible]	[illegible]	- " -
[illegible]	Purification of [illegible] products	[illegible] exchangers [illegible]	- " -
31.	Catalysis of organic reactions	- " -	- " -
[illegible]	Separation of amino acids, [illegible]	[illegible] cation exchangers	- " -
34.	[illegible]	All [illegible]	clinic.
[illegible]	Chemical analysis	- " -	labor.
[illegible]	Wine purification	cation exchangers anion exchangers	in operation
[illegible]	Removal of [illegible] from hydrochloric acid	strongly basic anion exchangers	- " -
37.	Purification of formalin from acids	Anion exchangers AN-1	Industrial

The above list of fields of application does not pretend to be complete and is only an illustration of the multitude of possibilities of ion exchange. It includes only such fields of ion exchange which have gone [illegible] from laboratory investigations to industrial application. It is difficult to mention any branch of science and technology where ion exchange is not used in this or that scope. The scale of production of ion exchangers is mainly determined by the requirements of water treatment comprising 75 % of the total consumption of ion exchangers. Being the oldest field of ion exchange application, water treatment, at present, has reached a technical perfection. Being developed first for the power stations it has now penetrated all the fields of human activity. At present, for example, water softening is used for the water purification of power [illegible], [illegible] textile, radio and [illegible] industries, [illegible] and engineering, [illegible] and so on.

Anion exchanger water softening, developed in the recent years, enable to purify water from the content of fluorine, chloride and other [illegible]. At present, it has been found through investigation, that drinking water should contain from 1 to 2 mg/l of fluorine substances.

Higher amount of fluorides leads to teeth decay. However in some countries: Algiers, Tunisia, Spain, Italy, South America, [illegible] some regions of the USSR fluoride content [illegible] exceeds this figure. Anion exchanger water softening is an efficient means of the removal of surplus amount of fluorides. With this aim in view strongly basic anion exchangers in chloride form are used. The scale of its application [illegible] large [illegible], undoubtedly, very soon it will find its proper place in the utilization of ion exchangers. Deionization and demineralization of water through ion exchangers were developed much later as compared to water softening, and in the recent years have become the sole methods of water treatment. At present considerable increase of the content of organic substances in natural water is observed, which [illegible] serious complications in the utilization of ion exchangers. The composition of organic impurities is different for various sources and is variable throughout the year; this presents difficulties in developing efficient methods of their removal. Such universally accepted methods of pre-treatment of water as chlorination, coagulation, filtration, [illegible], while being absolutely necessary in the majority of cases, however, do not always provide the required degree of purity. In the process of water purification, organic material [illegible] on the surface of ion exchange resins [illegible] are not removed completely through ordinary regeneration. [illegible] of organic impurities are of polar nature, [illegible]; however, their high molecular weight makes their sorption difficult. Gradual contamination of ion exchange resins takes place, particularly [illegible] the [illegible] character of resins, leading to the reduction [illegible] efficiency of [illegible] purification, and growth of reagent consumption for the regeneration and washing of the resins. Anion exchangers [illegible] II. [illegible] exchangers being efficient with relatively pure water from the point of [illegible]

[illegible] when coming into contact with contaminated water. [illegible] of organic [illegible] in the water of high purity [illegible] [illegible] [illegible] [illegible] has been suggested to fight the [illegible] after the final [illegible] for the [illegible] [illegible] organic [illegible] to be regenerated with [illegible] (for example [illegible]). [illegible] anion exchanger [illegible]-17 [illegible] cross-linked [illegible] suggested [illegible].

According to [illegible] for the [illegible] of chemical demineralization of water, a [illegible] of [illegible] anion exchanger (critical [illegible]) is suggested. [illegible] merits of [illegible] with ordinary [illegible] [illegible] absorbed organic [illegible]. The [illegible] degree [illegible] [illegible], however, [illegible] [illegible] in order to achieve [illegible] all living organisms.

[illegible] exchanger [illegible]-1 [illegible] successfully [illegible] the brightening of [illegible] through the use of [illegible] exchanger [illegible]. [illegible] children is [illegible] through [illegible]-1. [illegible] from [illegible] purified with [illegible]-1 [illegible].

[illegible] exchangers [illegible]-[illegible], [illegible]-1[illegible], [illegible]-1[illegible] [illegible] used in the [illegible], even when [illegible].

However, with [illegible] [illegible] [illegible] [illegible] [illegible].

studied for [illegible] [illegible] [illegible]tion – hygi[illegible] [illegible]. Ion [illegible] have become very important for the purification and [illegible] of [illegible] (streptomycin, tetracyclin, penicillin and other [illegible]). [illegible] ion exchangers [illegible] – 2, [illegible]-2, [illegible]-2, [illegible] [illegible] used. [illegible] ger [illegible]-2-[illegible], is used in the purification of [illegible]. [illegible] cyclic cation exchangers are used for [illegible].

Industrial introduction of [illegible] implemented (among other [illegible], uranium, [illegible] and so on). The [illegible] out of ores [illegible]. [illegible] ion exchangers produced [illegible] used for this purpose. [illegible]-[illegible] [illegible], [illegible]-1[illegible], [illegible]B-17, [illegible]-1[illegible], [illegible]-1, [illegible]-[illegible], liquid [illegible] ion exchangers [illegible].

Ion exchangers [illegible]-2, [illegible]-1 are widely used in [illegible] for the purification of [illegible] vegetable waters.

Lately, ion exchangers are being widely introduced into the chemical industry:

cation exchanger [illegible]-[illegible] is used [illegible] of the [illegible] the production of [illegible] for the [illegible] [illegible]le [illegible]; [illegible] manufacture of [illegible] and diphenyl[illegible] ion exchangers [illegible]-[illegible] and [illegible]-1[illegible] are used for the purification of [illegible] [illegible]-[illegible] and [illegible]-1[illegible]-[illegible] [illegible] of caprolactam; [illegible]-[illegible] – for conversion of [illegible] chloride [illegible] nitrate, [illegible] of liquid [illegible].

Ion exchange fabrics and fibers as well as [illegible] ion-exchangers are becoming very important; process technology of their manufacture and fields of their application are being studied at present.

Of great importance now are ion exchange resins for the purification of radioactive waters, for the extraction, purification and separation of radioactive substances, causing extensive and [illegible] the influence of ionizing radiations upon ion exchange materials. [illegible] ion exchange resins in analytical chemistry [illegible] diversified [illegible]. [illegible] demonstrate the diversity of ion exchange [illegible] fields [illegible] do not exhaust all of them. [illegible] utilization of [illegible] ion exchangers [illegible] various fields of application ([illegible] – 19[illegible]) [illegible] below.

Field of application	Consumption of ion exchangers of the total volume, %
[illegible]	[illegible]
[illegible]	3,[illegible]
[illegible]	12,[illegible]
[illegible]	3,5
[illegible]	1[illegible],[illegible]
[illegible]	1[illegible],[illegible]

[illegible] exchange membranes

[illegible] in regions of the [illegible] severe shortage of fresh water encountered in their economic development. On the other hand there are large sources of saline water in these regions. Therefore extensive work is going on in a number of [illegible] with the view to develop efficient methods of saline water desalination. Among the [illegible] promising method is an electrodialysis utilizing ion exchange membranes, however the industrialization of the principle advantages of this method depend upon the properties of ion exchangers, their price and service and also upon the degree of perfection of the [illegible] for electrodialysis.

[illegible] desalinators with the daily capacities ranging [illegible] 2[illegible] m^3 desalinated water has been developed in the Soviet Union. When being under [illegible] these units have shown the data confirming high economic efficiency of the electrodialysis. Electric power consumption [illegible] electrodialysis for the manufacture of 1 m^3 of desalinated water from the water of underground springs (containing [illegible] g/l of dissolved salts) [illegible] 1.3 kw/hour and respectively 3.[illegible] – 5.[illegible] kw/hour in case of 13.[illegible] g/l salt content. Guaranteed life of membranes is 3 years.

Table 2

[illegible]in properties of heterogeneous membranes

Description	[illegible]	[illegible]	[illegible]
Static exchange capacity, mg-eq/g	2.3-[illegible]	[illegible]	[illegible]
Selectivity in 0.1/0.2 n solution of sodium chloride [illegible]	[illegible].9[illegible]-[illegible].9[illegible]	[illegible].93-[illegible]	[illegible]
Specific volumetric resistivity ohm/cm	1[illegible] - [illegible]	[illegible] - 2[illegible]	1[illegible] - 1
Specific surface resistivity ohm/cm^2	9.[illegible] - 12	1[illegible] - 1[illegible]	[illegible]
Swelling power, [illegible] thickness	11[illegible] - 13	12[illegible] - 13	1[illegible] - 1[illegible]
Thickness, [illegible]	[illegible]	[illegible]	[illegible]
Dimensions, [illegible]	1.5 [illegible]	1.5 [illegible]	1.[illegible]

The qualit[illegible] of demineralized water is high [illegible] fully [illegible] the require-ments of USSR standards for drinking water, does [illegible] harmful addi-tives and is [illegible] for good [illegible].

Achievement of such data was made possible through wide investigations resulting in industrial manufacture of heterogeneous reinforced [illegible] MK-4[illegible], M[illegible]-4[illegible], [illegible]-1. [illegible]in properties of these membranes are given in [illegible] 2.

At present extensive works in [illegible] the range of products, impro-ving their properties and reduction [illegible] are carried on.

This will enable [illegible] organics and utilize them effectively [illegible] solutions, purification of liquid effluents and [illegible]. [illegible] new [illegible] are given in table 3 and [illegible].

Table 3

[illegible]
[illegible]
([illegible])

Description	[illegible]			
	[illegible]	[illegible]	[illegible]	[illegible]
1	[illegible]	3	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]Cl, [illegible]	[illegible]	[illegible]	[illegible]–12.[illegible]	12.[illegible]–17.[illegible]
[illegible]	1.[illegible]	1.[illegible]	1.[illegible]	1.[illegible]
[illegible]	[illegible]	2.[illegible]	2.[illegible]	2.[illegible]

1. [illegible];
[illegible]

2. [illegible] solution of [illegible]Cl [illegible] [illegible].95–[illegible].9[illegible] and [illegible].93–[illegible].95 for the [illegible] respectively.

3. [illegible] for the [illegible] of the given [illegible].

Table 4

[illegible]

Description	[illegible]–1[illegible]	[illegible]–10[illegible]	[illegible]–1[illegible]	[illegible]
[illegible] g-c[illegible]	2.5–2.[illegible]	2.[illegible]–2.[illegible]	1.[illegible]	[illegible]
[illegible] 1:2n-solution of [illegible]Cl, [illegible]	[illegible].5–[illegible]	[illegible]	[illegible]	[illegible].9[illegible]
[illegible] solution of [illegible]Cl, ohm.c[illegible]	1[illegible]–1[illegible]	1[illegible]–1[illegible]	2[illegible]	1[illegible]
[illegible] electric resistivity [illegible]	2.[illegible] – 5	3.[illegible] – [illegible]	[illegible].35	1.[illegible]
[illegible]	11[illegible]–11[illegible]	11[illegible]–11[illegible]	12	18[illegible]
[illegible] m2/g	12–1[illegible]	12–19	13	1[illegible]
[illegible]	.2	[illegible].2	[illegible].3	1.[illegible]

[illegible]

[illegible] wide range of [illegible] - recover[illegible] polymeric [illegible] (electr[illegible] [illegible]gers) and [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]-recover[illegible] [illegible] [illegible] exchange [illegible] ties (electron [illegible] exchanger[illegible]) [illegible] developed in the U[illegible]. It w[illegible] possible through th[illegible] [illegible] [illegible] industrially complete removal [illegible] dissolved oxygen from the water. [illegible] of oxygen from the water is of [illegible] importance for the corrosion reduction [illegible]. [illegible] of the [illegible] [illegible], [illegible] oxygen removal, small consumption of reagents [illegible] the regeneration of electron exchange [illegible] rials [illegible] such [illegible] method of oxygen removal from the water through electron exchangers [illegible] [illegible] [illegible] utilizing chemical reagents (for [illegible], hydrazine, morpholine, etc).

Electron exchangers [illegible] [illegible] [illegible] for [illegible] oxygen removal from [illegible]cess water utilized for the [illegible], [illegible] [illegible] polymerization. [illegible]val of oxygen traces from this water provides [illegible] controlled polymerization and [illegible] processes [illegible] [illegible] [illegible] effect upon the quality of the polymers [illegible]uced.

Along with these important fields of application electron exchangers will find utilization in non-ferrous metallurgy, [illegible] chemistry and biochemistry.

Materials which have found [illegible] utilization and can be manufactured industrially are given below.

EI - 5 - electron ion exchanger obtained through deposition of finely dispersed copper upon sulfonated coke, [illegible] absorption power on oxygen equal to [illegible] kg/m^3

EI - 12 - electron exchanger obtained through deposition of finely dispersed copper upon cation exchanger [illegible] [illegible] [illegible] absorption power on oxygen equal to [illegible] kg/m^3

EI - 15 - electron exchanger with capacity on oxygen equal to [illegible] kg/m^3

EI - 5b - electron exchanger with capacity on oxygen equal to [illegible] kg/m^3

[illegible] - 5 - electron exchanger, obtained through condensation of hydroquinone. Capacity on oxygen - [illegible] kg/m^3. During oxygen removal soluble additives are not [illegible] and the product can be reversibly recovered.

[illegible]-11 – electron exchanger, obtained through the formation of complex compounds of [illegible] and ion exchangers, [illegible] by cation exchanger KU-2.

Specific [illegible] – [illegible] – 7 kg/m^2.

Modification of [illegible] is achieved through the utilization of other complex[illegible] / [illegible]-12 – cation exchangers [illegible]-10, [illegible]-12 on the basis of [illegible] cation exchanger [illegible].

Summing up, [illegible] large industry of ion exchange materials capable of satisfying everyday requirements of the main branches of national economy has been set up in our country. The range of products includes sulfonated coals, synthetic ion exchange resins, ion exchange membranes, electron and electron-ion exchangers [illegible].

Conclusion

1. Ion exchange [illegible] with the [illegible] of the technical progress.

2. Polymeric reagents (ion exchange resins, membranes, electron exchangers) are absolutely necessary for a number of branches of science and technology. Development of [illegible] industry in [illegible] is [illegible] without them.

3. Manufacture of polymeric reagents is not a large tonnage production. It amounts to 10,000 tons (calculated to dry weight) in most developed countries.

4. For the [illegible] of polymeric materials [illegible] developed raw material base (styrene, divinylbenzene, amines, chloromethyl ester and so on).

Capital investments are considerable. The price of products greatly depends upon the scale of production.

5. Developing countries are rather large consumers of polymeric reagents. Development of their manufacture is possible only under conditions of cooperation of a number of developing countries, the range manufactured being closely [illegible] with the [illegible] of [illegible] industry development in these countries. However, taking into account the relatively small scale of consumption in each of the developing countries for the near future, the purchase of these materials from the developed countries probably might be more expedient.

6. The USSR is prepared to [illegible] the manufacture of polymeric reagents ([illegible] exchange resins) as well [illegible] ment, antibiotics purification, [illegible] of waters from [illegible].

7. Until the manufacture of [illegible] veloping countries the USSR [illegible] units on the basis of trade agreements [illegible].

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