ionic content of water (fig. 2). Two flat sheet membranes, one that preferentially permeates cations and the other, anions, are stacked alternately with flow channels between them. Cathode and anode electrodes are placed on each side of the alternating stack of membranes to draw the "counter" ions through the membranes, leaving lower concentrations of ions in the feedwater [1].

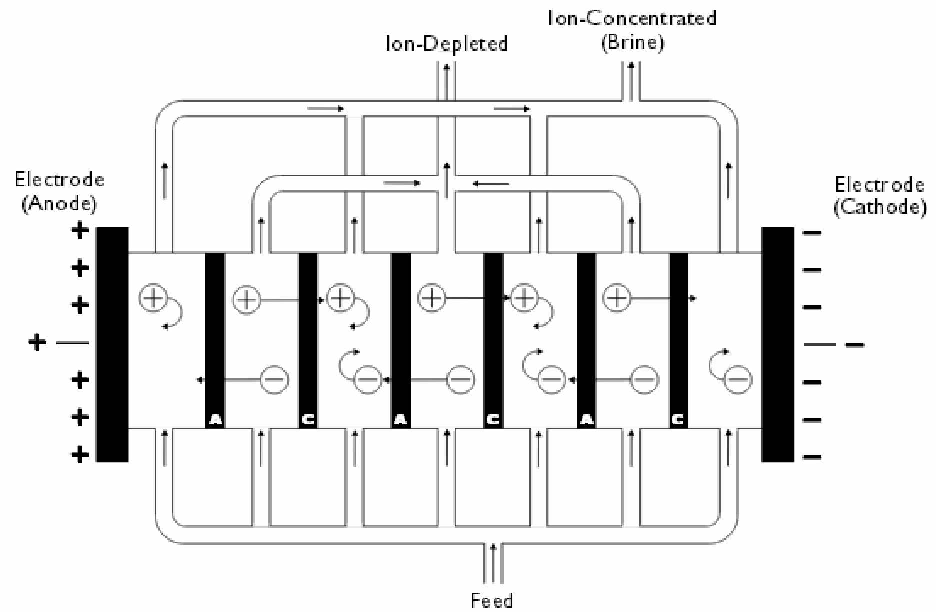

Fig. 2. Electrodialysis

The efficiency of electrodialysis depends on the ionic solids and fouling potential from organics and particles in the feedwater, the temperature, the flow rate, system size and required electrical current. Organics and weakly-charged inorganics are not removed by ED. Recent developments have improved the efficiency of ED by reversing the polarity of the electrodes periodically.

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ABOUT THE APPLICATION OF INORGANIC MEMBRANES IN MODERN INDUSTRY

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Separation systems are a vital part of most industrial processes. These systems account for a large fraction of the equipment and operating costs of industrial processes. Inorganic membranes have the potential for providing separation systems that can reduce both equipment and operating costs. Some optimistic thoughts will be given on how several industries can be operationally and economically revolutionized with inorganic membranes systems. Some examples of developments of new technology will be given.

Separation systems are a vital part of industrial processes. These systems account for a large fraction of the equipment and operating costs of industry. Separation processes are needed for everything from feed stock materials to pure end products. Inorganic membranes have the potential for significantly reducing both the equipment and operating costs associated with these separation. In addition, there is a serious emerging systemic problem of how to reduce or eliminate waste and environmental pollution created by these processes. Inorganic membrane separations can recover and recycle materials; this will significantly reduce or eliminate waste streams.

Where are inorganic membranes now? Ten years ago industry all over the world showed a great deal of excitement about the potential use for inorganic membrane. Jean Charpin, in his plenary address to the First International Conference on Inorganic Membranes, gave the French CEA (*Commissariat à l'énergie atomique*) credit for that industrial interest in inorganic membranes because of their technology transfer program. It was very well deserved credit. The release of their inorganic membrane, an outgrowth product from their gaseous diffusion program, was a major contribution. It has stimulated a very large amount of new research. That program, which began in the late 1980s, gave the first commercially useful inorganic membranes. While there is a significant current market for the French membrane (manufactured by the French Company SCT and marketed by the US company *US Filter*), it is limited to a few special applications in nano- and ultra-filtration and its cost is high. Since then, there has been a large amount of useful research including modifications of the French membranes that resulted in demonstrations of large separation factors at a broad range of operating conditions. However, the availability of new commercial inorganic membranes has been very disappointing. Commercial development has been slow and the cost of methods to produce new membranes continues to increase. Industry appears to be losing much of the earlier excitement for the promise of inorganic membranes. Some experts (North American Membrane Society annual meeting, May 1994) believe that useful inorganic membranes simply are not viable. Nevertheless current research is gaining momentum. It has broad ranging, innovative, and producing good promising results and significant new exciting scientific information. Now some words about need of inorganic membranes for acceptance by industry. There are a number of criteria essential for inorganic membranes to be accepted by industry:

1) Large separation factors are needed to achieve economical enrichments in a single stage. The use of multiple stages is always a possible means for achieving a desired enrichment (e.g. uranium enrichment by gaseous diffusion), but multiple stages greatly reduce the economic potential.

2) High permeance is needed to reduce the size of the stage. However, the permeance of inorganic membranes is not as serious a problem as is usually perceived. The perception is that a large amount of membrane area is needed to produce a given amount of product. Large areas of organic membranes (spiral wound or hollow fibers) can be assembled into a given size module. Because of the configuration of inorganic membranes (usually tubes), the perception is that a much larger module is needed to assemble enough membranes to achieve the same throughput. For a given module size, organic membranes can be assembled with 1,000 to 10,000 times the amount of membrane area than can be achieved with inorganic membranes. But it is also true, for many applications, that inorganic membranes can be produced with 1,000 to 10,000 times the permeance of organic membranes. Therefore, it is reasonable to expect that the size needed to produce a given volume of product is about the same for inorganic membranes as for organic membranes.

3) Cost of the membrane modules must be reasonable and competitive. At present, the cost per unit area of inorganic membranes is about 100 times greater than the cost per unit area of organic membranes. However, as in the case above, if a given module requires 1,000 to 10,000 times more area than the inorganic module to produce a given volume of product, then the inorganic module would cost less than the organic module with respect to the amount of membrane required by the module for the same output. Because of this large difference in the permeance and thus smaller membrane area required for inorganic membranes, it is perhaps not appropriate to price inorganic membranes by the unit area.

4) Reliability is generally recognized to be inorganic membranes best advantage. They can be expected to have significantly longer useful lifetimes. They can be used in much more harsh corrosive environments. In addition, the openness and favorable hydrodynamics that can be achieved with smaller areas of inorganic membranes can significantly reduce fouling problems.

In order to achieve acceptance by industry, it is essential that scientists concentrate on developing practical working systems that can demonstrate the cost effectiveness and reliability of inorganic membrane systems.

The above comments were not intended to imply that inorganic membranes should be considered competition for organic membranes, only that the difference in cost is not nearly as large as is generally perceived. I do believe that inorganic membranes will eventually replace many of the organic membrane (but not all). However, at present, the most important applications for inorganic membranes are in processes for which the organic membranes cannot be applied. The major advantage of inorganic membranes is their operating range. That operating range includes high and low temperatures, high and low pressures, and all kinds of corrosive environments. The operating condition range not only allows the inorganic membrane to be used in these harsh environments, but also adds more freedom to the design of separation processes. By choosing the appropriate inorganic membrane and operating conditions, given processes can be optimized in terms of separation factors, permeance, and cost effectiveness.

In order to achieve a given separation, it is essential to choose a process in which the components have velocities that are as largely different from each other as can be achieved. Ideally, the component to be separated should have a velocity high enough to be economical, and the other component or components should have a zero velocity. The real beauty in inorganic membranes is the large number of transport mechanisms that can be utilized. These many transport mechanisms provide a large number of parameters that can be considered in designing an inorganic membrane to achieve a given separation. Included are such parameters as the physical and chemical properties of the material used, pore size, void fraction, and membrane operating conditions. When designing membranes it is important to have a theoretical basis for the design process instead of using the Edisonian or trial and error approach.

Inorganic membranes have the real potential for revolutionizing a large number of industries. That revolution can be in terms of the way the industry functions, the cost of doing business, the safeness of doing business, and the environmental soundness of doing business. Efficiency improvements and revolutionary changes can be made in many industries and separation processes such as those shown in the tables below.

Table 1 – Application of inorganic membranes in different industries

Industry	Application
Environmental Restoration	Recovery and Decomposition
Food Processing	Sterilization and Heat Recycle
Gas Production	Low Cost Purification, Replace Distillation
Microelectronics	Low Cost Ultrapure Water
Petrochemical	High Yield Membrane Reactors, Replace Distillation
Petroleum Refining	Recover and Recycle Hydrogen, Replace Distillation
Pulp and Paper	Closed Cycle Processing, Recovery from Waste Streams
Waste Management	Volume Reduction, Recycle
Water Purification	Sterilization, Ultrapurification, Replace Distillation

Table 2 – Potential for successful implementation of inorganic membranes for separation different substations

Separation Process	Potential For Successful Implementation of Inorganic Membranes
Hydrogen From Coal Gas	Excellent
Hydrogen From Methane/CO_2	Excellent
Hydrogen From Catalytic Reactors	Excellent
Photocatalysis	Excellent
Micro-Ultra-Nano Filter	Excellent
Cleanable Gas or Liquid Filters	Excellent
Reverse Osmosis	Excellent
VOCs From Air	Good
CO, From Methane	Fair
Nitrogen From Methane	Fair
Oxygen From Air	Fair

Inorganic membranes have great flexibility for assembly into almost any size module for commercial applications. For example, a small module might be made to produce a few gallons per day of potable water for home use. A large example might be a module assembled to produce millions of pounds per day of enriched natural gas. A real example of such a commercial size is a diffusion stage, near the feed point, in the U.S. gaseous diffusion plant where the interstage flow is about 100 million pounds per day when the plant is running at full power. The modular structure of the membrane units can be adapted to almost any configuration and environment for specific applications.

In conclusion we can say this paper presents beginning formalism towards understanding transport mechanisms important in engineering the design of inorganic membranes for the discussed applications and many more. The gaseous diffusion process for enriching uranium isotopes, still used around the world, has shown that inorganic membranes can be manufactured on a large scale. Inorganic membranes' potential for producing a new industrial revolution depends on the ability to understand and choose transport mechanisms, to precisely engineer membranes, to economically manufacture them and to rapidly transfer the appropriate technology to industry. National laboratories and private industry must form partnerships and begin working together doing what each does best in cooperative agreements to share their individual expertise in order to accomplish this goal.

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MECHANICAL CHARACTERISTICS OF SINTERED HARD ALLOYS WITH CARBIDE LAYERS

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Cutting tools made of hard alloys allow to improve the processing of parts for their cutting speed is 2-4 times higher than that of the tools made of high speed steel (HSS). In addition to this, a solid carbide tool can process hard materials that are difficult to process or not treatable at all by a HSS tool. The operational stability of carbide inserts is greatly influenced by mechanical properties changing during the deposition of carbide layers by CTP. This paper deals with the study of the mechanical properties of hard alloys with carbide layers.

In the process of thermochemical treatment of standard grades of carbide it is a change of chemical composition and structure of the surface layers, as well as the occurrence of internal stress, which has a certain influence on the mechanical and cutting properties of hard alloys.

Diffusion saturation surfaces of the insert of hard alloys simultaneously by two or more elements (multicomponent saturation) allow a much greater modification of the properties of the surface layer than that of the one-component saturation.

Cementation process is conducted in alumothermal mixtures on separate embodiment, a preliminary restoration of the mixture at a temperature of 800 – 1100◦C using reagents classification "chemically pure", "W".

Before performing the processes carbide plate was degreased, and then packed in a refractory vessel with a saturating mixture. For sealing the container shutter fuse boric anhydride was used. Maintaining the desired temperature in the furnace was realized automatically during the process of saturation.

The performance properties of the alloys with carbide deposited layers are influenced by the strength of adhesion layer with the substrate material, the ability of the diffusion layer to withstand static and dynamic loads, the absolute value and the nature of the residual stress distribution in the layer [1].

The study found that there is an optimum thickness of the diffusion layers, equal to 3.10 microns, at which mechanical properties of coated carbide maximized. The sharp decrease in values for carbide layers thicker than 10 microns says the deterioration of the adhesive strength of the layers obtained with the base, the accumulation of structural stress, the nature of the phase, which leads to chipping layer.

Carbide cutting process is a subject to high unit loads (both static and dynamic). For this reason, the output of their failure often occurs as a result of mechanical failure, which is why the mechanical properties of hard alloys largely determine their performance characteristics.

The most common measure used in the evaluation of mechanical properties of hard alloys is tensile strength transverse bending (determined according to GOST 20019-74).

The samples are used for testing ground capping (size 5 × 5 × 35 mm carbide TT20K9 GOST 3882-74). Tests were concentrated load applied at mid-span at the loading rate of 1 mm/min. Tensile strength transverse rupture was calculated by the formula:

$$\sigma_{изг} = \frac{M}{W}, \qquad (1)$$

where M is a maximum bending moment; W is a moment of resistance.

For specimens of rectangular cross section transverse bending

$$M_{изг} = \frac{F \cdot l}{4}; \qquad (2)$$