GAS PURIFICATION SYSTEM

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Abstract

^{3}He recovery and purification system based on a special polymer film was developed and purified gas was analyzed by a quadrupole mass filter with a differential pumping system.

1. Introduction

All cyclotron has to equip a recovery and purification system at the acceleration of ^{3}He particles due to a high cost of ^{3}He gas. The purification system usually is based upon absorption by liquid nitrogen cooled absorbents. RCNP AVF cyclotron also equipped the purification and recirculation gas handling system. Alternative He recovery and purification system was developed and was tested.

2. Principle of purification

Principle of ^{3}He purification is based upon different permeabilities of various gas on the polymer film. Diffusion of gas through the wall of the polymer thin tubes is described by the equation;

$$\frac{dqi}{at} = K_i \frac{A \cdot \Delta p}{d}$$

where, $\frac{dqi}{dt}$; gas flow rate at STP

K_i ; permeability constant

A ; total surface area

Δp ; pressure difference across the tubing wall

d ; wall thickness.

The permeability constants for He, N_2 and O_2 are $K(He)=1.4\times10^{-10}$, $K(O_2)=3.9\times10^{-12}$, $K(N_2)=5.2\times10^{-13}$. The large difference of between He and O_2, N_2 suggests to purify He from contaminant gas.

3. Gas purification and analyzing system

The system for gas purification used a special polymer film offered by Nippon Sanso Co. It is mainly composed of diffusion sells and diaphragm compressors. Gas circulation under almost the same condition as the cyclotron gas handling system was simulated by a large vacuum chamber(3000 ℓ), an evacuating diffusion pump(3000 ℓ/min) and a leak tight rotary pump. Gas analysis system was composed of a quadrupole mass filter, a variable conductance value and a small chamber evacuated by a diffusion pump (Edward Diffstak 160/700 with santovac-5 fluid). The system is shown in fig. 1.

4. Operation and results

Purified gas was introduced into a small chamber at pressure of $\sim5\times10^{-8}$ Torr through a variable conductance valve. If there are residual gas in the chamber, the chamber was heated with tape heaters up to about 200°c. After

evacuating for 5 or 6 hours, pressure of the chamber came to 10^{-8} Torr. A typical measurement has been done under the vacuum of about 5×10^{-8} Torr at analyzing chamber and 500 Torr at exit of purification system. Before and after mass analysis, partial pressure of residual gas in the chamber at analyzing system has been measured. After purified gas was sampled by a variable conductance valve and the measurement of mass analysis was completed, partial pressure of purified gas was obtained from the difference between the analysis of residual gas and that of purified gas. In order to know the purification of output depending on that of the input gas, several mixtures of helium and argon were tested. The results are as follows;

Input Gas		Output Gas	
He	Ar		He/other gas (%)
3.0 cc/min	1.0 cc/min	2 cc/min	98.0
2,0	1.0	"	98.0
2.0	2.0	"	97.0

If the helium content is larger than 50%, purity of gas can be expected to be over 97%.

Another test at making large leak at a chamber has been done. Gas circulates from a chamber with a leak tight rotary pump to purification system and gas flow rate into a chamber was regulated by an electro-magnetical gas flow controller. At the helium gas flow rate of 1 cc/min, purification of helium was about 97%. After measureing it about 3 lus argon gas was introduced into a chamber, the mass analysis has been measured during one hour. In that analysis, the purification of helium decreased to 96% and partial pressure of H, H_2O increased by about 1% respectively, but argon was not observed. When the more leak about 60 lus was introduced, 0.6% argon was detected. The system, recently was operated with cyclotron and it worked successfully.

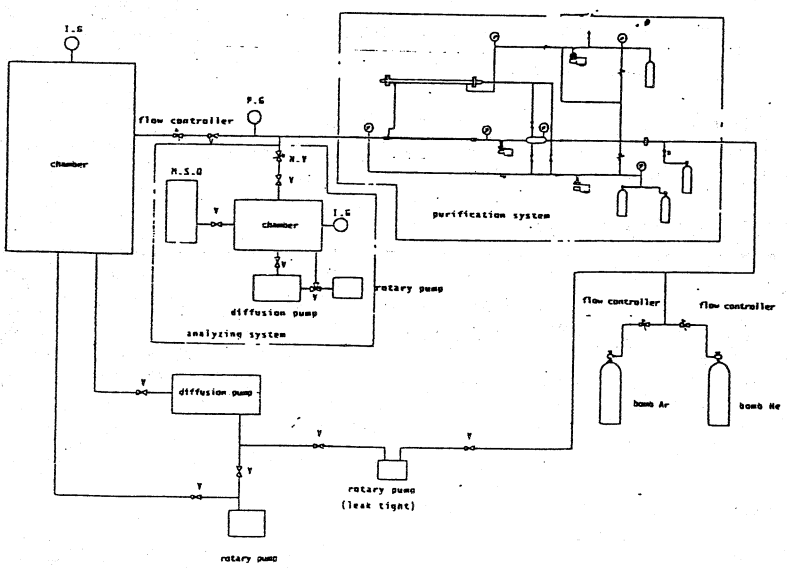

Fig. 1. Gas purification and analyzing system