EVALUATION OF THE W-VALUE OF VARIOUS GASES INCLUDING He-3 AND H-2 USING TRITIUM BETA PARTICULER

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1. Introduction

A new technique was studied and developed to aim at precise determination of W-values[1-4] of various gases using unit litter ionization chambers and tritium, which emits low energy β-ray. What was studied and developed :
(1) Ionization chamber and measuring gases filling system were designed and constructed. Characteristics of the ionization chambers were observed.
(2) Wall effect was examined.
(3) Effects of hydrogen as impurity on the ionization current were examined.
(4) The W-values of $^1H_2$, $^2H_2$, ^3He, ^4He, N_2 and Ar were respectively estimated.

2. Experimental Method

2.1. Ionization Chamber

The cross-sectional view of the measuring ionization chamber is shown in Fig.1. The chamber consisted of a stainless steel cylindrical high voltage supplying electrode and a collecting electrode, which was set on the central axis of the cylinder. The two electrodes were air tightly connected by pure alumina insulator with a guard ring. The inside of the cylindrical chamber was well polished like a mirror finish. The ionization chamber was electrically isolated from the filling system by the insulator tube.

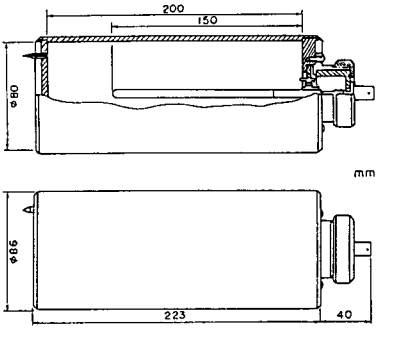

Fig.1 Unit litter ionization chamber

2.2. Measuring System

The block diagram of a measuring system is shown in Fig.2. Current measurements were made of a vibrating-reed electrometer. The ionization chamber electrodes were joined to the preamplifier of the vibrating-reed electrometer with a flexible shielded co-axial cable. The guard ring was operated at the level of the ground potential. A high voltage source supplied negative voltage from zero to 5kV to the cylindrical electrode.

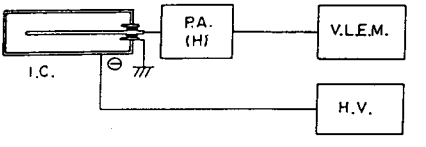

Fig.2 Block diagram of measuring system

I.C.: Ionization chamber, P.A.(H): Preamplifier of vibrating-reed electrometer, H.V.: High voltage supply, V.L.E.M.: Vibrating electrometer

2.3. Gas Filling System

The schematic diagram of the gas filling system is shown in Fig.3. This system was used for supply, recovery and storage of various gases and tritium gas. The system composed of stainless tubing, tube fittings and metal bellows valves, was joined to a vacuum pumping system. The gas filling system was evacuated routinely below 3×10^{-7}mbar. Tritium gas was supplied from a glass ampoule with a breakable seal. Tritium gas was stored into four unit litter vessels. Then, tritium in the vessel was conducted into an empty ionization chamber at first. Measuring gas was added to it.

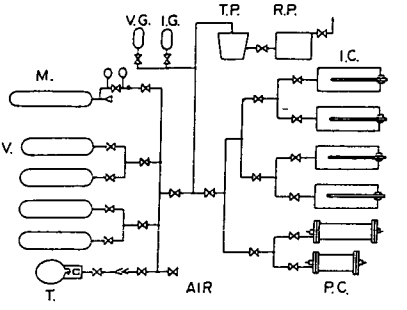

Fig.3 Schematic diagram of gas filling system

R.P.: Rotary pump, T.P.: Turbo molecular pump, V.G.: Baratron gage, I.G.: Ion-gage, M: Measuring gas container, V: Cylinder vessel, T: Tritium ampoule, I.C.: Ionization chamber, P.C.: Proportional counter

2.4. Gamma-Ray Irradiation

The γ -ray irradiation facility, which has 89TBq of ^{60}Co, belongs to Nagoya University. The ionization chambers were installed at a distance of 2.0m from the center of the ^{60}Co source.

2.5. Experimental Procedure

Saturation curves of various gases filled in the ionization chambers were measured. Tritium filled in the vessel was introduced to four ionization chambers at the same pressure to repeat other gases in the same procedure. Then, $^{1}H_2$, $^{2}H_2$, ^{3}He, ^{4}He, N_2 and Ar were added into the each ionization chamber at 5×10^{3}mbar respectively, afterwards, negative potential was applied to the cylindrical electrode and elevated stepwise. The collection current was measured out in each chamber. Measurements of the wall effect of various gases were carried out. In the same tritium content, ionization currents were measured by stepwise increased pressure and various gases respectively. Used tritium was provided a mixture of $^{1}H_2$ and $^{3}H_2$. In order to examine impurity effect in the gases used in the chambers, ionization currents of the chambers filled with mixed gases, $N_2 + {}^{1}H_2$ and $Ar + {}^{1}H_2$, were measured in the ^{60}Co γ -ray field.

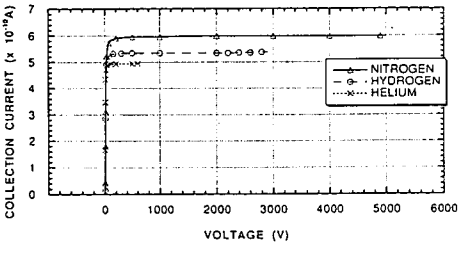

Fig.4 Saturation curves

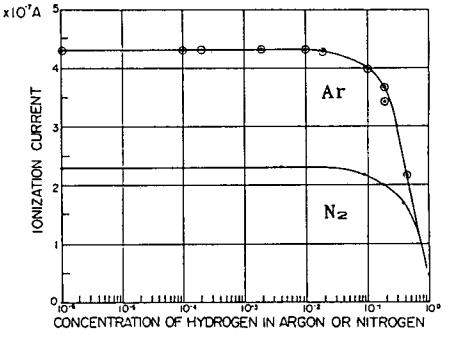

Fig.5 Ionization current versus concentration of H_2 in N_2 & Ar

3. Results and Discussion

3.1. Saturation Characteristics

The saturation-currents on N_2, H_2 and He are shown in Fig.4. The voltage ranges of the flat saturation-currents on N_2, H_2 and He were 5×10^2 to 4.9×10^3, 2.0×10^2 to 2.8×10^3 and 5.0×10 to 6.0×10^2V at 5.0×10^3mbar respectively. The ionization chambers were operated at the middle voltage of each range.

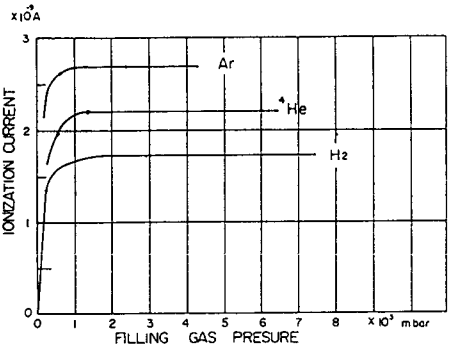

Fig.6 Ionization current versus filling gas pressure

3.2. Effects of Impurity Hydrogen

The ionization currents versus to hydrogen concentration in argon or nitrogen by γ -ray irradiation are shown in Fig.5. The ionization currents were unaffected below 1% of hydrogen mixture. Therefore, each character of the ionization chamber was unaffected to add $^1H_2$ & $^3H_2$ below 10^{-2}% in measuring gases.

3.3. Wall Effect

Results of the measurement of the wall effect are shown Fig.6. The ionization current decreased as low as to the pressure of the measuring gas. The decreased current was mainly occurred by absorption of tritium β-ray on the chamber wall. Though the wall absorption was decreased at high pressure. Above 1×10^3mbar, the ionization currents were saturated. The wall effect was neglected above the 2×10^3mbar.

From above results, the W-values of the various gases will be obtained by the techniques easily. The W-values of N_2, $^1H_2$ and He were estimated 34.6, 37.0 and 43.5eV respectively.

4. Conclusions

From the above experimental results, it was concluded that the tritium adding method was satisfactorily used to measure the ionization current in the various gases to determine the W-values. The conclusions about the present studies are the followings;

1) Ionization chambers were designed and manufactured.
2) A metallic gas filling system was constructed.
3) Saturation-currents on N_2, H_2 and He were flat over a wide voltage range.
4) When the gases contained hydrogen below 1%, the ionization current did not change, in the case of γ-ray irradiation.
5) Wall effect was neglected at pressure above 2×10^3mbar.
6) W-values of N_2, $^1H_2$ and He were obtained and the value of other gases will be reported at the IRPA9.

References

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