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RESUMO

Êste trabalho descreve a construção e operação de um contador proporcional a fluxo de gás para contagem alfa e beta.

Foram feitos estudos no sentido de aplicar o gás de uso doméstico (LPG) como gás de contagem. Com a finalidade de prolongar a vida do detetor foi dada ênfase especial ao tratamento químico do gás.

Êste contador, operando com gás LPG, vem trabalhando rotineiramente e exibindo ótimos patamares para contagem alfa e beta, tendo sido a vida do eletrodo bastante prolongada graças ao tratamento químico adequado do gás.

RÉSUMÉ

On a ici décrites la construction et l'opération d'un compteur proportionnel à flux de gaz pour la mesure des rayonnements alpha et beta.

On a étudié l'application du gaz en bouteille comme un gaz de comptage. Pour prolonger la vie du détecteur une attention spécialle a été donnée au traîtement chimique du gaz.

Ce compteur qui fonctionne continuellement utilisant le LPG présente des excellents plateaux pour le comptage alpha et beta. La duration du détecteur a été grandement prolongée à cause du traîtement chimique approprié du gaz.

SUMMARY

The construction and operation of a proportional gas flow counter for alpha and beta counting are described.

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Studies were made with the purpose of using domestic kitchen gas (LPG) as the counting gas. In order to extend the detector's life special emphasis has been given to the chemical treatment of the gas.

This counter is in routine work using the LPG as counting gas and exhibits very good plateaux for alpha and beta counting. The duration of the detector has been largely increased due the convenient chemical treatment of the gas.

I - INTRODUCTION

This paper describes the construction and performance of a proportional gas flow counter for alpha and beta counting. The counter, based on Sugarman's model, was built at the Radiochemistry Division of the I.E.A., where it is in routine work.

The proportional counters present some advantages over Geiger-Müller detectors, such as the ease with which their integrant parts are machined, owing to what its substitution is possible whenever it is necessary. Another great advantage that we have with this home-made counter is that the counting gas used is the liquified gas (LPG) for domestic use, much more convenient, available and cheaper, than the counting gases or mixtures of gases normally used, such as pure CH_4 or 90% A-10% CH_4 mixture that must be imported. Besides that, the proportional counter can deal with much higher counting rates than the Geiger-Müller counter does.

II - INTEGRANT PARTS OF THE COUNTER

The counter body is cylindrical and was built in brass.

The anode is a loop of 2 mil stainless steel wire, this being the most delicate part of the counter and special care should be given to the condition of uniformity of the wire used.

A standard insulator of teflon is used to connect the high voltage cable to the anode.

The choice of the window to be used is particularly important when alpha counting is concerned. For example: a window of mylar aluminised on both sides which is 1 mil thick, cuts off completely alpha radiation.

In the early experiments windows of gold coated VYNS which total thickness was about 25 $\mu g/cm^2$ after coating were used. These windows have good conditions for both alpha and beta counting, however, they are extremely fragile for constant use.

For normal use windows of mylar aluminised on both sides which are 1/4 mil thick were adopted, since these, besides being very resistant have also good counting conditions, because their thickness is adequate to prevent absorption on it.

The counter body is fixed on the same support of lucite that has also the shalves to stand the radioactive sources for counting.

A lead castle of the common type is used as shielding, and for high tension supplying a Decade Scaler Nuclear Chicago Model 186-A is used. A little modification has been made on its electronic circuit and consisted in changing a resistance of 100 K ohm (R_1 in the original drawing) for another of 7,8 M ohm. A Super Scaler Nuclear Chicago Model 192-A have also successfully been used.

Its integrant parts as well as thewhole assembly are shown in figures 1, 2 and 3.

III - OPERATION

1. Counting gas: domestic kitchen gas.

Although pure CH_4 and mixture 90% A - 10% CH_4 are the more commonly used counting gases, this counter is being operated with the liquified gas for domestic use (LPG = mixture of propane and butane). This gas presents an excellent behaviour, that may be seen through the plateaux obtained for both alpha and beta counting, since they are long and or they are flat or their slopes are very small (0,2% / 100V). Fig. 4.

2. Gas Purification

It should be pointed out that with no treatment at all of the gas, notable plateaux are got. Although, a chemical treatment of the gas is necessary since the sulphur compounds present on it are nocive to the anode, shortening its duration. It is known that the active coal derived from coke and anthracite can remove the sulphurated compounds from the gas (1). Based on these properties the counting gas is purified by passing it through active coal, previously heated at 400^{o} C in a furnace, then through strong cationic resin that was also pre-heated at 100^{o} C, in order to retain moisture, and finally through silica-gel. To prevent dust deposit over the anode, a sintered glass filter is inserted in the gas line.

The gas flow is controlled by bubbling it in glycerin, as soon as it leaves the gas cylinder, then in sequence it passes through the coal, the cationic resin, and the silica-gel after what it penetrates the counter body.

IV - RESULTS

1. Plateaux

One of the ways of verifying the quality of a counter are the plateaux that it furnishes. So, the working conditions of this counter were established taking as reference the plateaux obtained.

1a. Beta Plateau

The beta plateau was ran with a source of natural uranium as U_3O_8 powder, spread out to 15 mm diameter on an aluminum counting tray. This source was covered with a thin aluminum foil to cut out alpha radiation. The plateau starts at 4.000 volts and ends at 5.000 volts, the operating voltage being fixed at 4.300 volts. Fig. 4.

Several other plateaux were carried out with beta emitters of different end point energies. The sources used were: S-35, Sr-90 and P-32. Fig. 5.

The natural uranium source was adopted as the standard source for routine testing of the counter.

1b. Alpha Plateau

The alpha plateau was ran with a source of Po-210 and lies in the range 3.000 to 4.500 volts. The operating voltage was fixed at 3.300 volts if a pure alpha emitter is to be counted,and at 3.000 volts in the case of a mixed alpha and beta source. Fig. 4 and 6.

1c. Alpha and beta plateaux

With a RaDEF source both alpha and beta plateaux were obtained. Concerning to beta plateau there is not any change, but the alpha plateau is shorter than the one carried out with the Po-210 source. Fig. 6.

2. Background

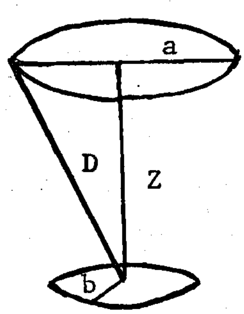
The background in the beta counting region is of about 20 cpm, and in the alpha counting region is of about 8 counts per hour.

3. Geometry

Our purpose is not to have absolute disintegration measurements with this counter, only relative counting being concerned. However, it is useful to know roughly what is the response of the counter, considering its different positions. So, a ^{90}Sr - ^{90}Y carrier free calibrated source mounted on a very thin VYNS gold coated film, was counted at the various positions available and the ratios between its counting rate at each position and its disintegration rate are shown in table 1.

As the energies involved in the measurements are high and the window used is very thin, the absorption on it is negligible; not being self absorption, since the source is carrier free, nor back scattering because the support used is the VYNS film, it may be said that the ratios corresponde to the Geometry factor.

The geometry has been calculated by using the following formula (2):



$$G_s = G_{p'} \left[1 - \frac{3}{8} b^2 \left[\frac{Z(Z+D)}{D^4} \right] \right]$$

$$G_{p'} = \frac{1}{2} \left(1 - \frac{Z}{D}\right)$$

Where: G_s = Geometry for a spread circular source of radius b.

$G_{p'}$ = Geometry for a point source.

The calculated values are compared with the experimental ones in table 1.

Table 1 - Calculated and observed geometry values

Z (mm)	G_s	$\frac{cpm}{dpm}$
2.6	0.40	0.40
6.6	0.26	0.27
9.6	0.19	0.20
19.1	0.08	0.09
22.6	0.06	0.07
35.1	0.03	0.03

V - DISCUSSION AND CONCLUSIONS

The counter above described has shown to be satisfactory for routine use. Concerning to the renewal of the gas cylinders there is not any trouble, since several cylinders have been used and there was not flutuation in the counting rate of the standard source taken as reference.

After a certain time of use, about 3 or 4 months, the anode must be substituted. Regarding the anode replacement there is not also any trouble. Several anodes have been used, and again, the counting rate of the U_3O_8 standard source taken as reference showed that there is no variation in the counting rate with the anode change.

The chemical treatment of the gas is of great importance and necessary to avoid very frequent change of the stainless steel anode. Many chemical reagents were used unsuccessfully for moisture and sulphur compounds removal from the counting gas: $Mg(ClO_4)_2$, strong cationic ion exchange resin, sulphuric acid, caustic soda solution, CaO, and active coal. The best dehydrating agents found were $Mg(ClO_4)_2$ and strong cationic ion exchange resin. The later was selected for its simplicity, efficiency, and safety. The $Mg(ClO_4)_2$ could retain some organic traces and become dangerous at the oven drying for re-use. For removal of the undesirable sulphur compounds contained in the gas, dried activated coal exhibited excellent performance. The other sulphur compounds removers used showed good separation but the counting rate or plateaux were disturbed.

SOME ASPECTS OF CHEMICAL TREATMENT OF THE GAS BY DIFFERENT CHEMICAL REAGENTS

1. NaOH

The gas passed through a 6M NaOH solution and then through a tube containing silica-gel in order to retain moisture.

This treatment was efficient regarding the removal of the sulphurated compounds, as could be seen through the loss of the characteristic smell, however, it was observed that after the treatment there wasn't anymore formation of the beta plateau (Fig. 7) and the alpha plateau was displaced to about 800 volts higher, compared with the one obtained with the untreated gas. The system was saturated with the gas during two hours before the measurement was made.

2. CaO

A tube containing CaO powder was placed along the rubber tubing through what the gas should pass. Again the system was saturated with the counting gas during two hours before the measurements and no plateau was obtained.

3. H_2SO_4

The gas passed through concentrated H_2SO_4 and before entering the counting system it passed through silica-gel to retain moisture. Also this treatment was efficient, as long as sulphur compounds removal is concerned, however, once more it is not adequate for the counting gas treatment since after passing through H_2SO_4 no plateau at all was obtained.

4. Active Coal

This substance showed to be very good for the gas purification since it is ease to be obtained, its performance in retaining sulphur compounds is quite satisfactory and it doesn't interfere with the measurements. Active coal is being used sucessfully for the routine operation of this counter.

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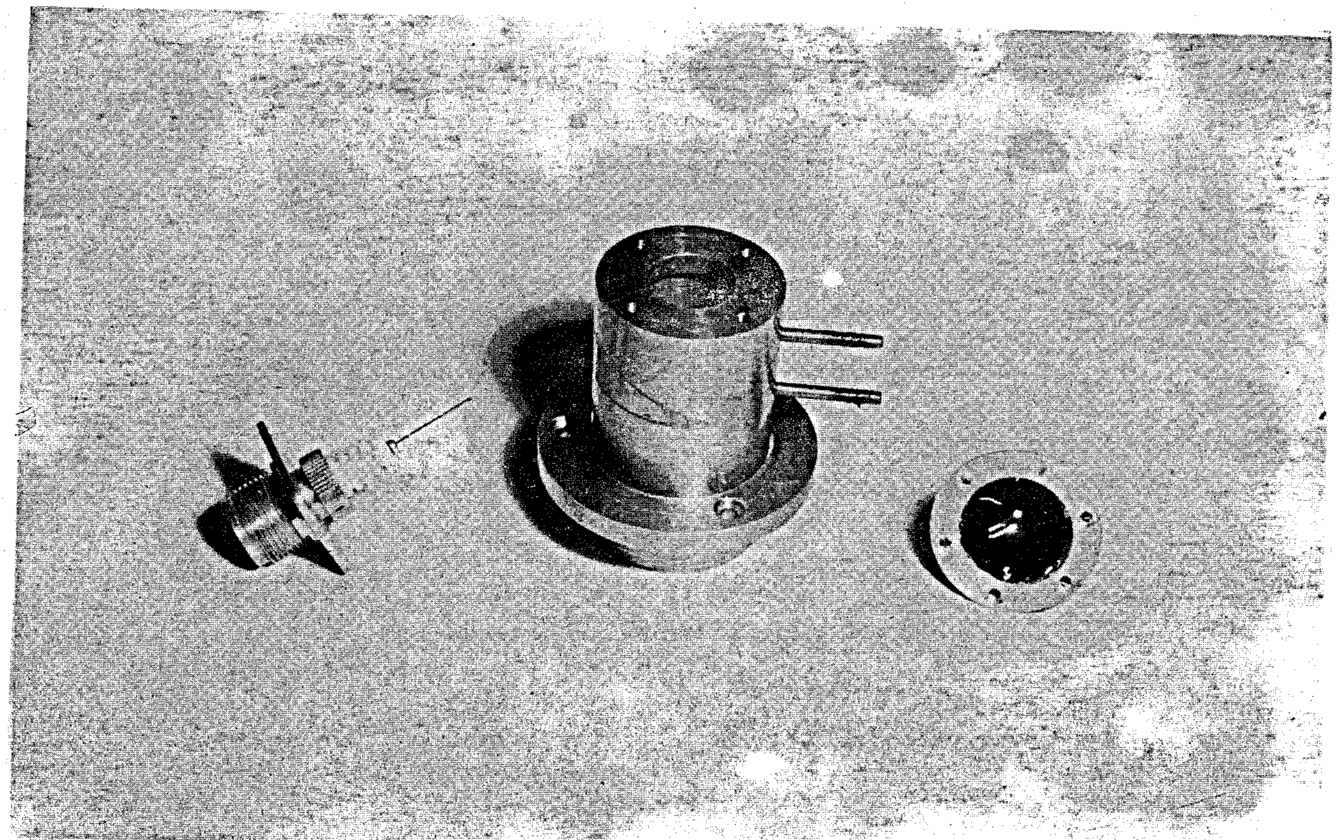

Figura 1

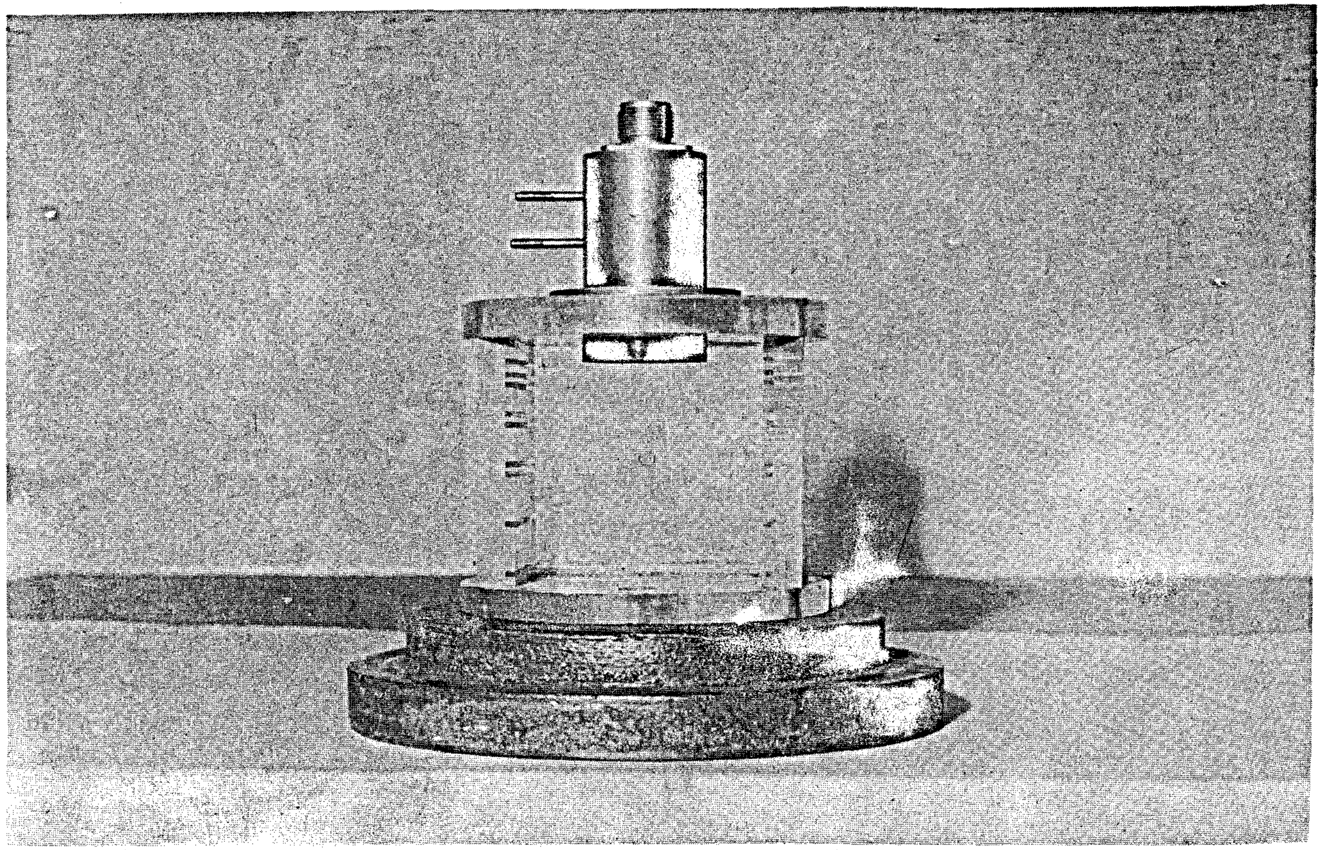

Figura 2

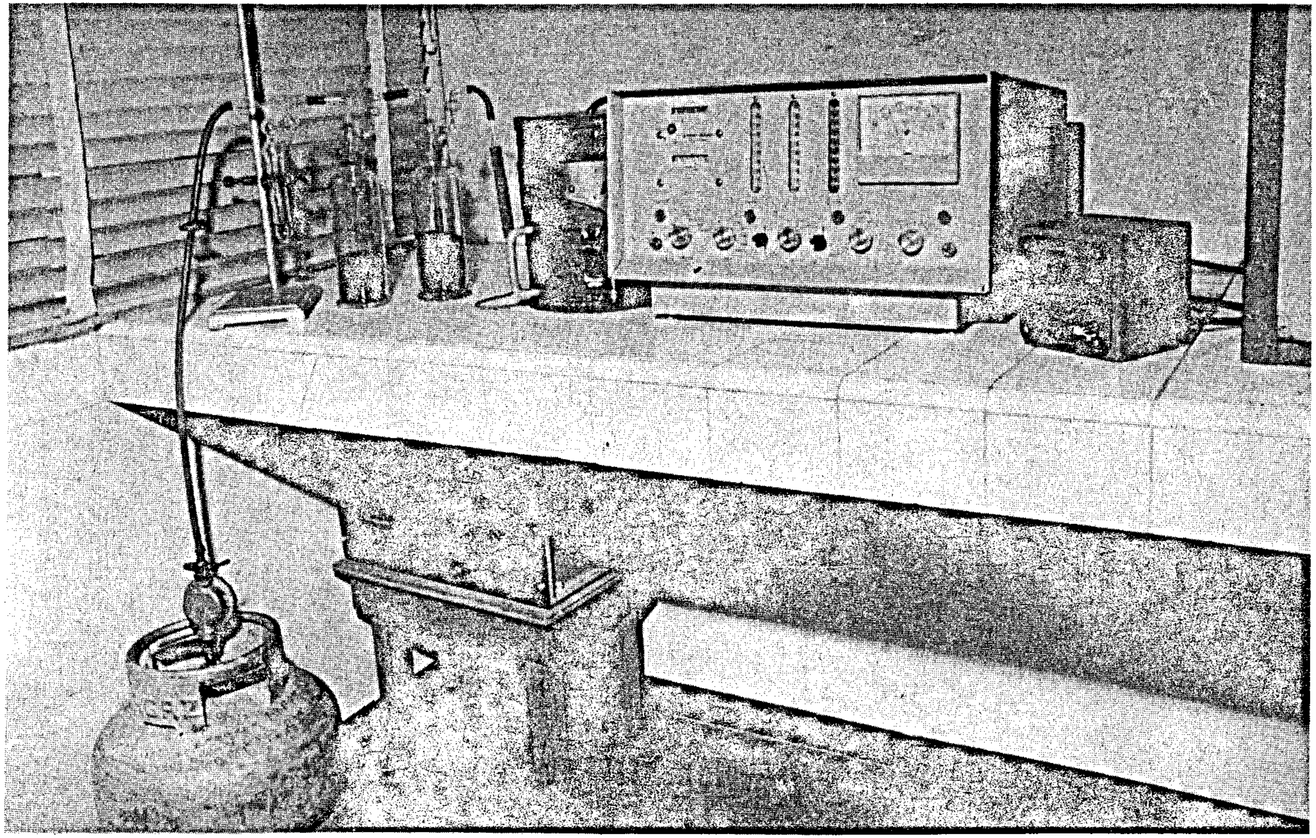

Figura 3

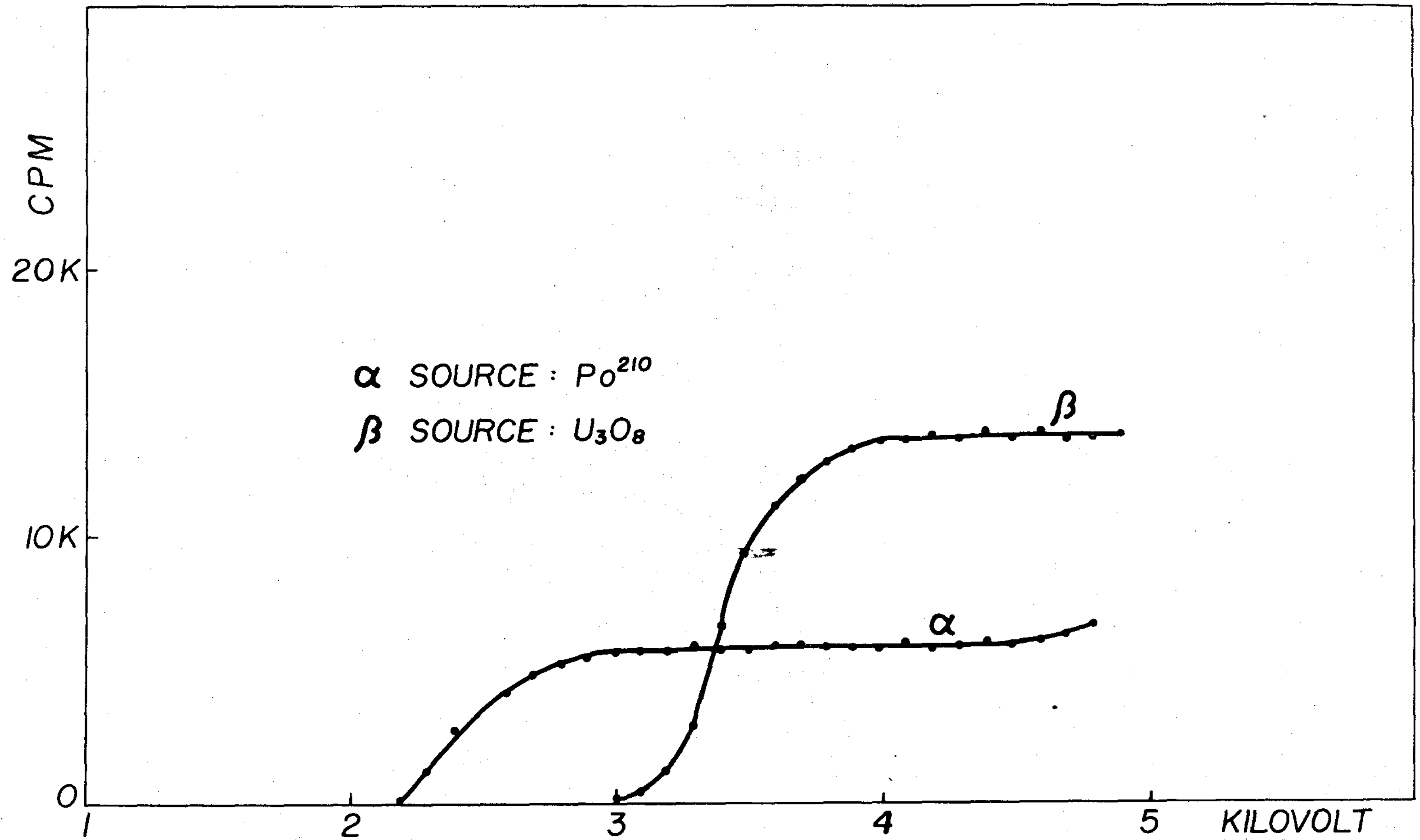

Fig. 4. α and β Plateaux

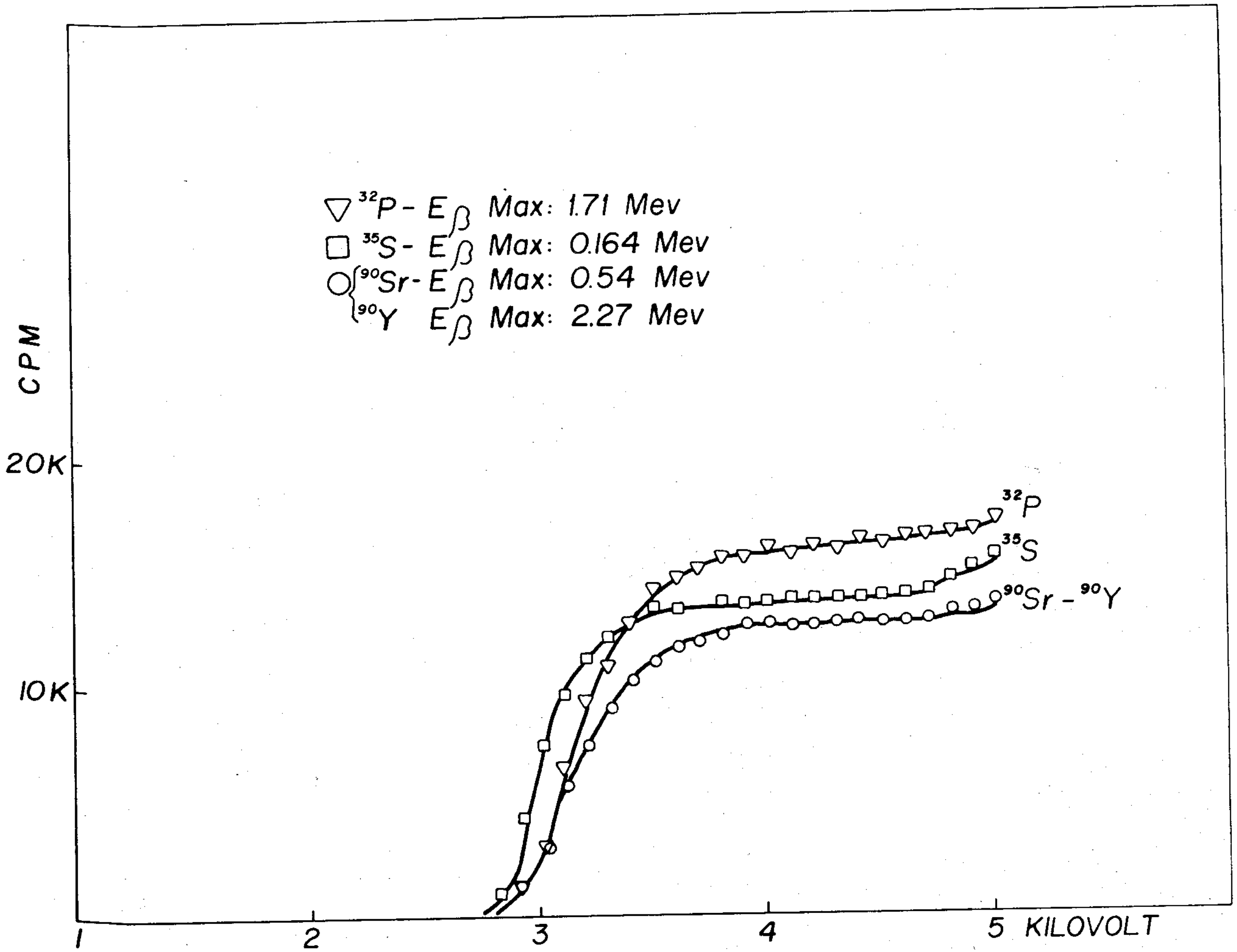

Fig. 5. Plateaux obtained for different β emitters.

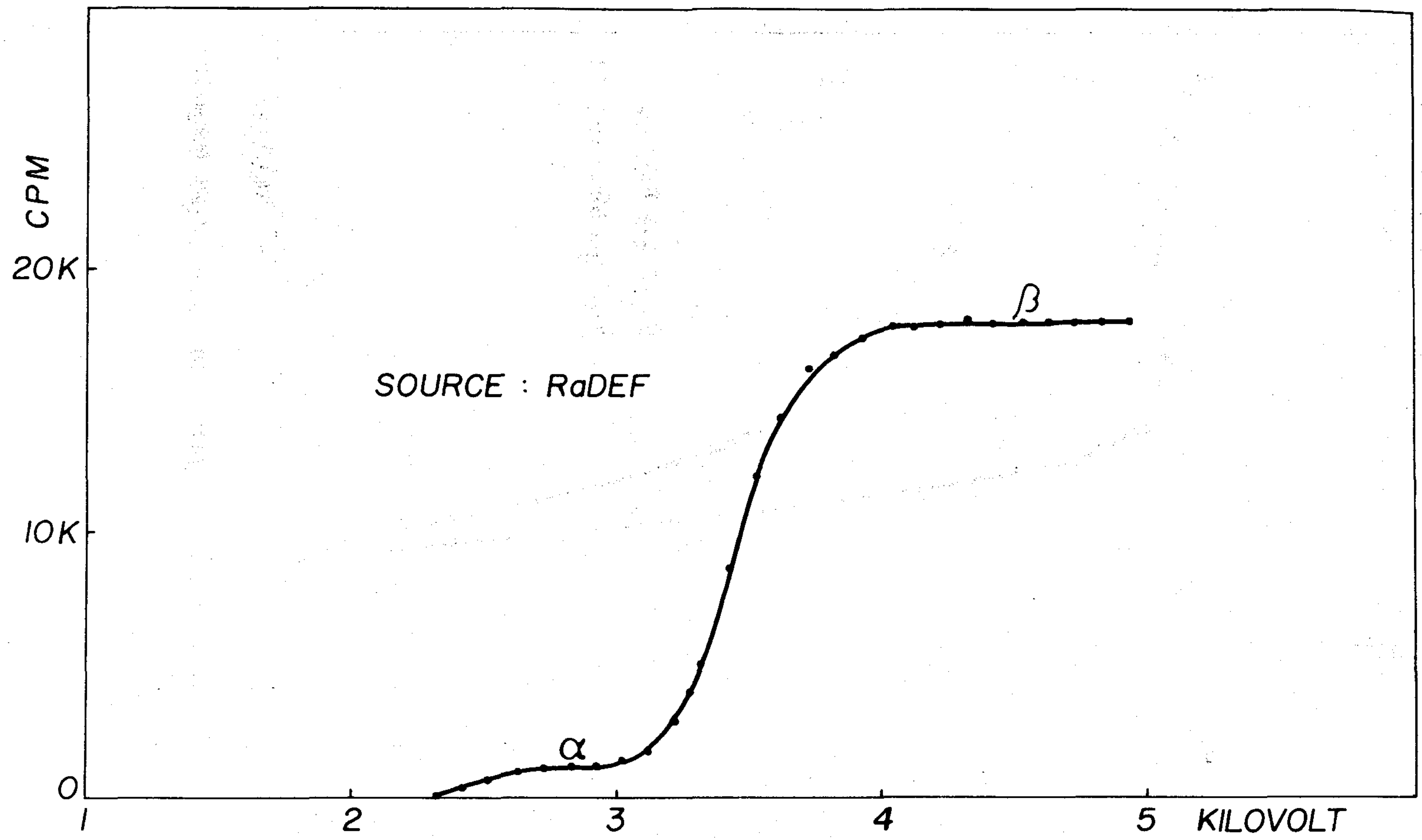

Fig.6

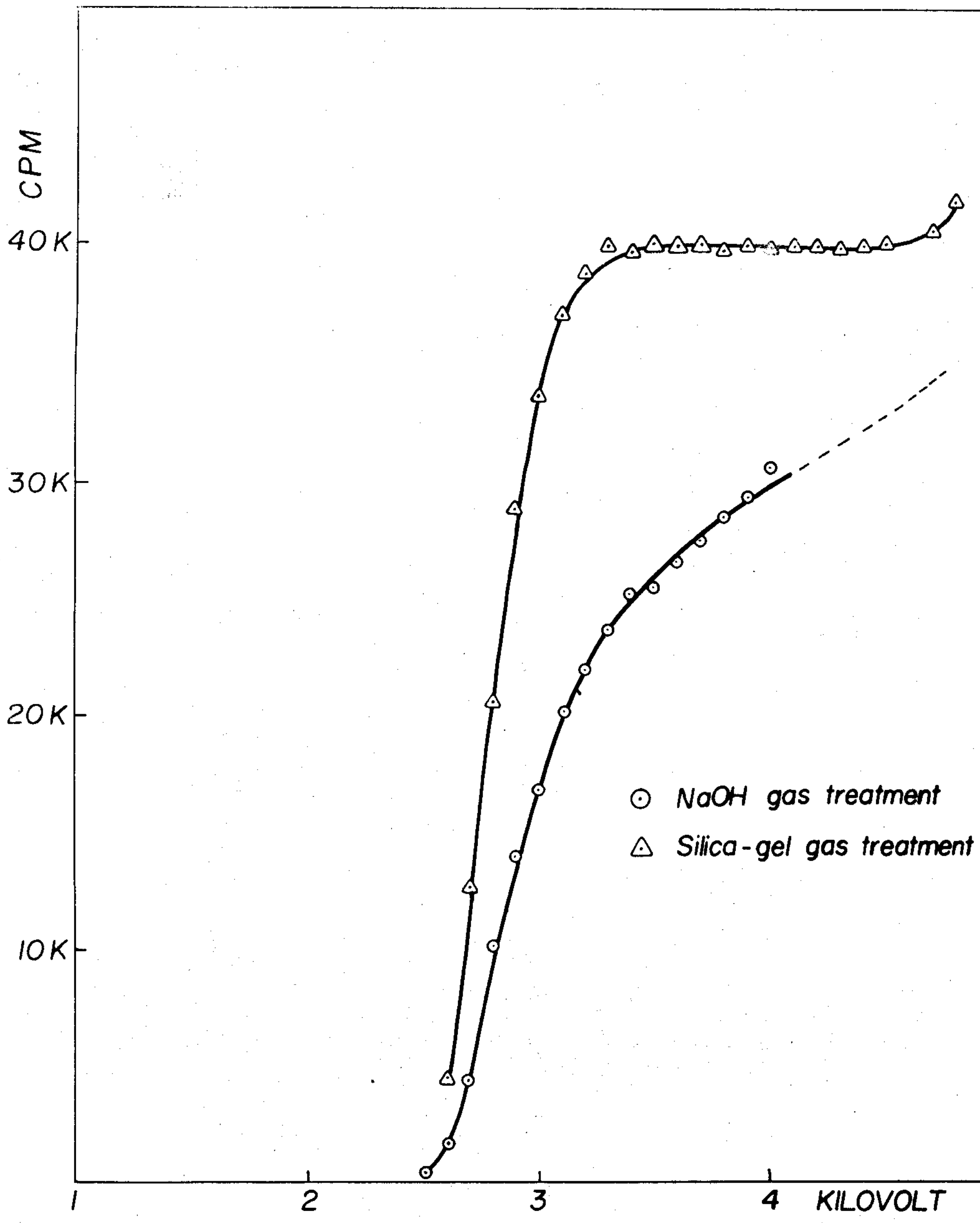

Fig. 7. Comparison between NaOH and Silica-gel gas treatment

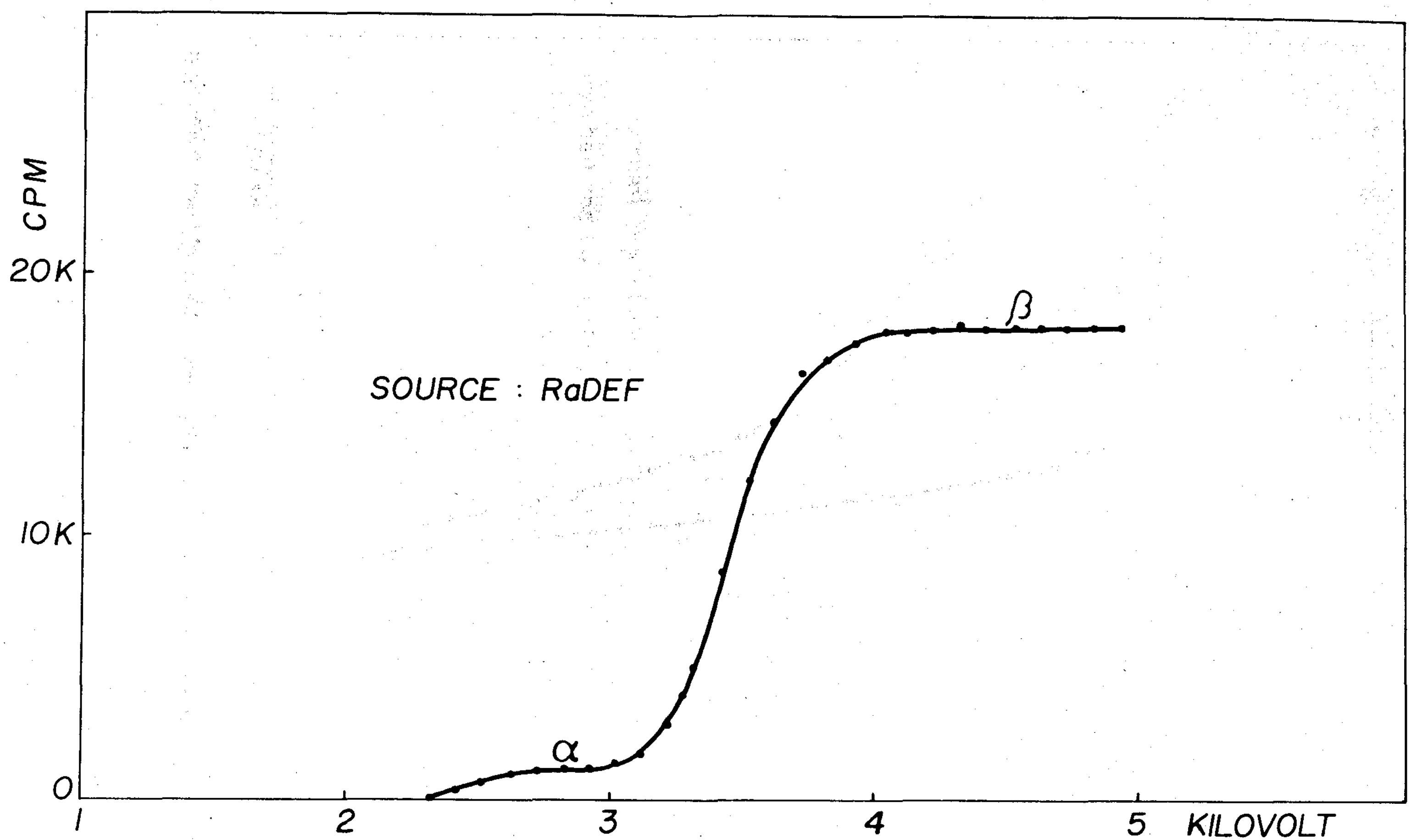

Fig. 6

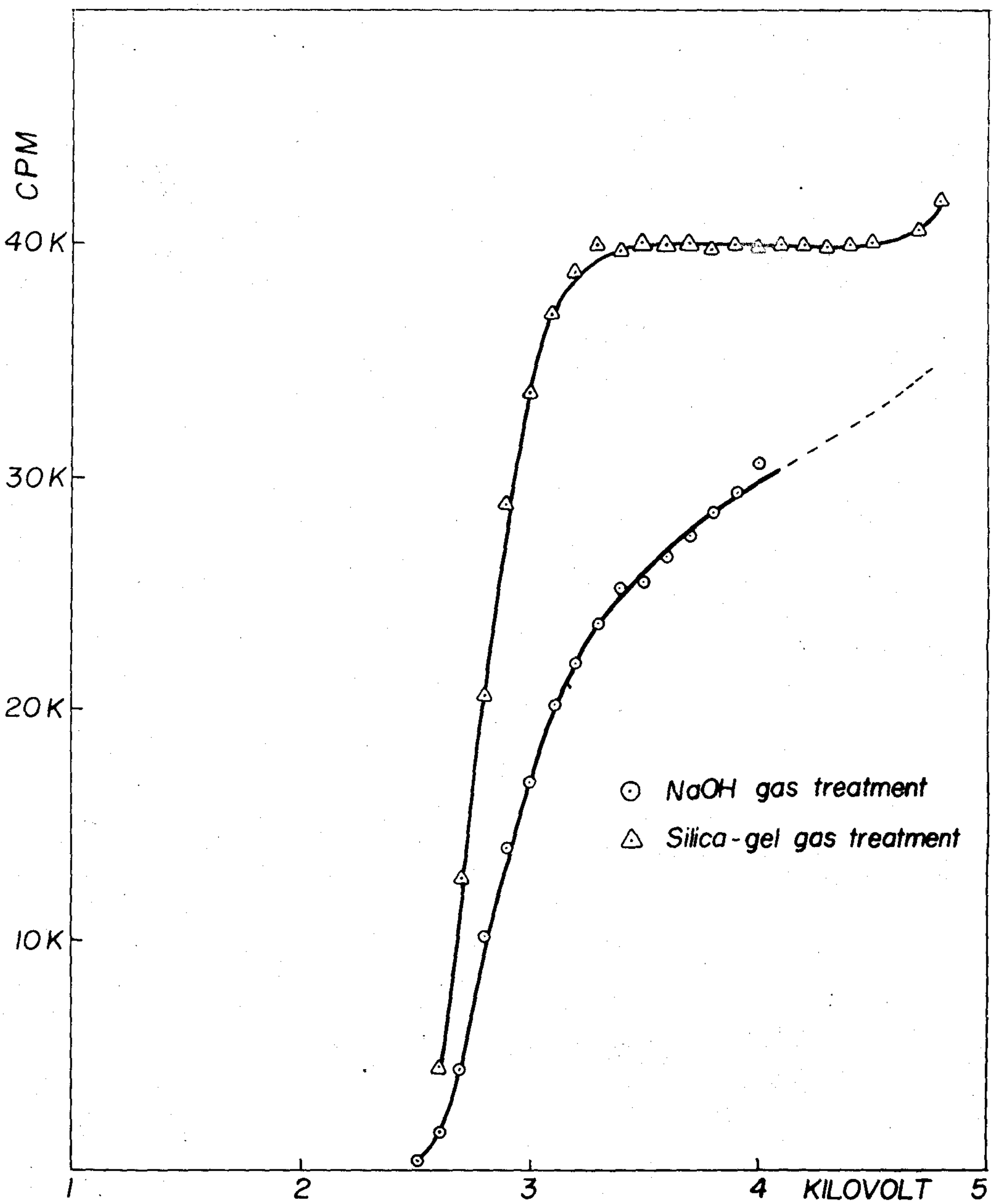

Fig. 7 Comparison between NaOH and Silica-gel gas treatment