DETERMINATION OF THE DETECTION LIMIT OF FLUORINE IN ALUMINIUM BY MEANS OF 14 MeV NEUTRONS

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ABSTRACT

A study relating to the determination of the detection limit of fluorine in aluminium by the use of fast neutron activation analysis and Ge (Li) detector was carried out. The amount of fluorine was determined by the measurement of appropriate full - energy peak originating from ^{19}O, produced through the $^{19}F(n,p)^{19}O$ reaction. The detection limit of fluorine was found as about 1000 ppm. in 6.1465 gr. aluminium sample.

ÖZET

Bu çalışmada hızlı nötron aktivasyon analizi ile ve Ge(Li) dedektörü kullanarak, alüminyum içindeki florun tespit edilebilirlik sınırı tayin edilmiştir. Flor miktarı $^{19}P(n,p)$ ^{19}O reaksiyonu neticesinde hasıl olan ^{19}O'un tam enerji pikinin ölçülmesi ile bu lunmuştur. 6.1465 gr. alüminyum içindeki florun tespit edilebilirlik sınırı ortalama 1000 ppm. olarak saptanmıştır.

INTRODUCTION

The aim of the present work is to develop a method for the routine analysis of fluorine in aluminium by the use of Ge (Li) detector. For this purpose, detection limits of fluorine by a reaction of

^{19}F (n,p) ^{19}O ..... (1)

must be established [2]. The fluorine analysis of aluminium is principally limited by two reactions occurring in the matrice element :

^{27}Al (n,p) ^{27}Mg ..... (2)

^{27}Al (n,α) ^{24}Na ..... (3)

If the sample is alloyed with magnesium, two other reactions interfere [1, 2].

^{24}Mg (n,p) ^{24}Na ..... (4)

^{25}Mg (n,p) ^{25}Na ..... (5)

However, for small amount of magnesium, such as 1 %, the reactions (2) and (3) become predominant.

In the determination of fluorine by means of ^{19}O, with half - life of 27 secs., principal interfering activity comes from ^{27}Mg, with a half life of 9.5 min.

Mathematically; the «lower limit of detection» is given in [3, 4] as :

$$L_D = U_1^2 + 2\,U_1\sqrt{2\,C_B}$$

where the parameter U_1 is a multiple of the standart deviation. For $U_1 = 1.645$, confidence level is 95 %. C_b is the background count that comes from the activity of ^{27}Mg in our experiment. The activities of ^{27}Mg and ^{19}O were determined by the decay curve analysis. The decay curve analysis permits a quantative determination of initial activities and half - lives of isotopes. For the complex decay curve, the half - life of the longest - lived isotope can be determined and by extrapolation, one can correct the shorter - lived activities for this contribution. The analysis can be performed either graphically or with the aid of a computer.

EXPERIMENT

The detection limit of fluorine in aluminium was determined by fast neutron irradiation of teflon and pure aluminium sample, and by measurement of formed activities using gamma - ray spectrometry consisting of Ge(Li) detector and multi - channel analyzer. Initial activity of ^{19}O and ^{27}Mg and their half - lives were measured by means of multi - channel scaling mode of analyzer.

The activity of ^{19}O formed by reaction (1) was measured from the full energy peak at 0.197 MeV. by Ge (Li) detector which has an active volume of 60 cm^3 and an efficiency of 10 %. The window width of single - channel analyzer was adjusted by taking the base width of the 0.197 MeV. photopeak. The activity of ^{27}Mg was also measured on the same window width. The interfering activity of ^{18}F ($T_{1/2} = 110$ min.), which performed by $^{19}F(n,2n)^{18}F$ reaction, in the determination of inital activity of ^{19}O and the interfering activity of ^{24}Na on the initial activity of ^{27}Mg were taken into consideration and corrections were made by decay curve analysis using the computer.

Teflon and pure aluminium, both being 2.35 mm in thickness and 35 mm in diameters, were used as the standart samples. The mass relation was 6.1465 gr. aluminium for 3.0542 gr. fluorine. A neutron generator, 200 kV - 1.5 mA. was used to produce 14 MeV. neutrons from $^3H(d,n)^4He$ reaction. The results were normalized by using the BF_3 neutron counter in paraffin wax which is placed close to the target of generator.

The irradiation, decay and measurement times for ^{19}O and ^{27}Mg were 30 - 60 sec., 40 sec. and 27 sec./channel respectively. Calculations were made by least squares fitting method with the aid of a computer.

RESULTS AND CONCLUSION

For the 0.197 MeV. photopeak of ^{19}O, the detection limit was given in Table — 1.

TABLE — 1. The detection limit of fluorine in 6.1465 gr. aluminium sample.

T_{ir} (sec)	$T_{1/2}$ (sec)	Detection limit (ppm.)
60	28.9	1025 ∓ 43
30	27.5	927 ∓ 50
60	26.7	1016 ∓ 71
30	27.4	1006 ∓ 47
60	27.9	1072 ∓ 37

The other method, to obtain the detection limit, is given by V. P. Guinn [5], which is based on the calculation of gamma-ray disintegration and counting rates depending on counting and irradiation conditions. Using this method, the detection limit of fluorine was calculated as 975 ppm. in 6.1465 gr. aluminium sample. This is in a good agreement with our experimental result.

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