Sulfur isotopes separation by using the molecular beam system

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Abstract

This paper was devoted to the enrichment of ($^{34}SF_6$) following the irradiation of the mixture of gases which consist (0.05 SF_6 +0.95Ar) in molecular beam system. Enrichment factors as a function of different lines of TEA CO_2 laser were studied, and the best line of irradiation was 10 P (16). Also the relation of stagnation pressures (corresponding of the adiabatic expansion temperatures) with the same factors at 10p (16) and 10p (20) were studied.

Keywords: TEA- CO_2 laser,SF_6 isotopes, selectivity , multiline of laser, dissociation of molecule

1-Introduction

The dissociation molecules in the field of high intensity CO_2 laser radiation [1, 2] have recently been found to be highly isotope selective process. First experiments performed with (SF_6) yield large enrichment factors for (^{34} SF_6) by selective photolysis of the (^{32} SF_6) component [3, 4]. The separation experiments also carried out with (SF_6) .They supplement and extend the previous studies [4,5]. The separation process was investigated using the (SF_6) molecules having neutral abundances of 0.042 (^{34} SF_6) and 0.95 (^{32} SF_6). The mixture was enriched with (^{34}S) by the dissociation of (^{32}S) which was governed by the spectral tuning range of the CO_2 laser. All that was made under the adiabatic expansion of gases by using the molecular beam technique. This method is to increase the selectivity by adiabatic cooling of gas and to remove the thermal sublevels [6]. For the high selectivity of lines from laser radiation was used to isotopes separation for another isotopes [7 - 15] . This paper, investigative the isotopes separation enrichment the (^{34} SF_6) and (^{32} SF_6) by molecular beam using pulse TEA – CO_2 laser .

2-Experimental conditions

A focused irradiation geometry was used to produce a strong field zone in which the molecules undergo dissociation. The CO_2 laser system has a grating which was used to select the vibrational-rotational lines of the laser ,and was then focused into a chamber by a lens having a focal length (100cm). The stainless-steel chamber was positioned such that the focus of the lens was located at its center of the molecular stream (internal diameter of chamber 40 cm). The interaction chamber (represents the third stage of the molecular beam system) was 100 cm long .This stage has NaCl window through which the laser beam was passed , mass spectrometer (optical engineering 16 A) was positioned on the other window. The enrichment factor (B) was calculated by the following equations after determining the concentrations of irradiation gas. [11,12]

$$B = \frac{R}{Ro} \quad ..... \quad (1)$$

where

$$R = \frac{[^{34}Sf_6]}{[^{32}Sf_6]} \quad \text{and} \quad R_o = \frac{[^{34}Sf_6]_o}{[^{32}Sf_6]_o} \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where (R_o) and (R) are the isotopes ratio before and after the irradiation respectively.

The pulse laser was synchronized with the pulse of gas by delaying the generator to increase the efficiency of irradiation. Finally all of the steps of irradiation were carried out under the best condition of supersonic flow of molecular beam [12].

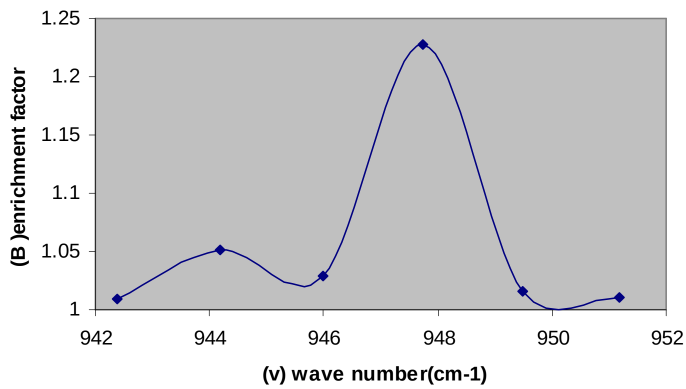
3-The results

The influence of the irradiation of the (SF_6) by high tense pulse from CO_2 laser was studied. Pulse repetition rate of laser equals (1Hz) with synchronized with gas injection pulse. The result from the signals were recorded by the mass spectrometer, the enrichment factor was calculated by using equations (1, 2).

3.1-Irradiation of gas by different lines

At this stage the mixture of gases (0.05 SF_6 +0.95A_r) was irradiated (A_r here was used as a carrier gas), by different lines of output laser ,and the corresponding enrichment factors were calculated and plotted as their function .

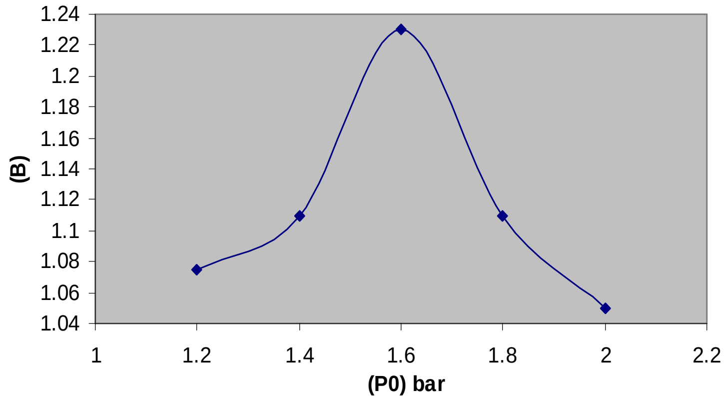
From figure (1), we can see that the best result was obtained when the gas irradiated by the line 10p(16) that corresponding to the wave number (947.73 cm^{-1}) .



Fig(1) illustrated the relationship between the wavenumber and enrichment factor

3.2-Variation of gas temperature with 10p(16)

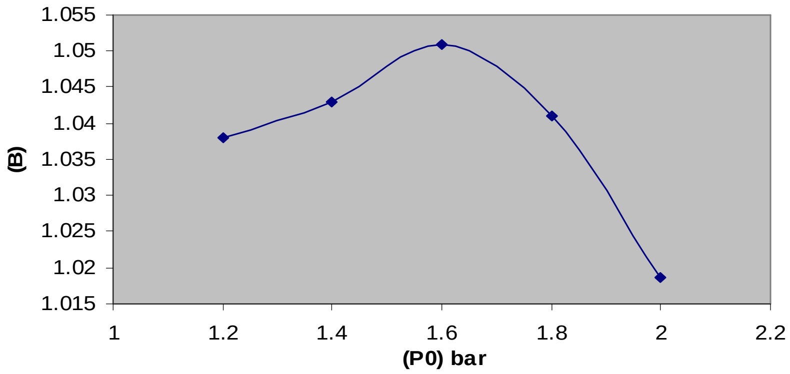
The previous step occurred under lowest value of temperature (33.4 K^o) which corresponds the stagnation pressure P_o (the pressure of mixture at the first stage of molecular beam system) . In this step the variation of (B) as a function of the stagnation that pressures was measured and plotted as shown in figure (2). From this figure we can see the high value of (B) was obtained with P_o equals to 1.6 bar in specific temperature (33.4K^o)



Fig(2) illustrated the relationship between the stagnation pressure and enrichment factor {at 10p(16)}

3.3-Variation of gas temperature with 10p(20)

At this stage the line 10p(20) was used as a irradiation line under the same conditions which were applied for the previous step . Then this relationship is also studied and plotted in figure (3).In this figure we can see the best value of (B) could be obtained under the lowest temperature (P_o equals to 1.6 bar).



Fig(3) illustrated the relationship between the stagnation pressure and enrichment factor {at10p(20)}

4- *Conclusions*

These experimental results have made it possible to answer many questions arising in the development of the system for isotope separation by isotopically selective dissociation of molecules in a strong infrared laser field .It has been shown that the best line we can use as irradiation line is 10p(16) because this line has the peak of absorption by the (^{32} SF_6) isotope .When the gas cooling by molecular beam system , the high selectivity of dissociation for certain isotope will be increased due to the thermal sublevels are removed under this condition. These results has been obtained for the first time in this procedure.

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الخلاصة

ركزت خطوات هذا البحث في إجراء عمليات التخصيب لنظير غاز سادس فلوريد الكبريت ($^{34}SF_6$) الأقل وفرة وذلك بعد تشعيع الغاز وبنسبة ($0.05SF_6+0.95Ar$) بليزر ثاني اوكسيد الكاربون. تمت دراسة العلاقة عامل التخصيب كدالة للأعداد الموجبة لخطوط الليزر ، وكان أفضل خط للتشعيع هو ((10p(16)) .كذلك درست العلاقة بين ضغط السكون للغاز وتأثيره على عامل التخصيب عند خطوط التشعيع نفسها.