Science in China Series B: Chemistry

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Can the decay rate of ^{32}P be changed by mechanic motion?

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The influence of mechanic motion on the decay rate of ^{32}P was studied by means of liquid scintillation counting (LSC). The results indicate that, on the Northern Hemisphere, the half life of ^{32}P in anticlockwise circular centrifuge rotation (radius 10 cm, 4000 r/min) equals the one in natural conditions within 0.6 percent uncertainty.

circular rotation, ^{32}P, decay rate

1 Introduction

Since radioactivity phenomenon was found, some studies have been made to see if the decay rate of some radioactive substance can be changed under various special conditions. In 1919, Rutherford and Compton studied influence of centrifugal fields (20000 g) on decay rate of radon, showing that the decay rate does not change within 0.1 percent[1]. In 1943, Freed reported that the decay rate of several types of decay processes had not changed in 5×10^5g centrifugal fields (radius 0.8 cm, 4000 r/s)[2]. In 2007, however, He et al. studied decay rates of radionuclide ^{32}P (β decay) and ^{111}In (electron capture) in external mechanic motion[3], and concluded that the half life of ^{32}P and ^{111}In can decrease or increase by external circular rotation in clockwise or anticlockwise centrifuge even only 2000 r/min (radius 8 cm). Moreover, the effect will be more marked when the rotate speed increases. When the clockwise and anticlockwise rotations increase to 4000 r/min, the half life of ^{111}In decreases by 11.31% and increases by 6.36%, respectively; the half life of ^{32}P decreases by 10.08% and increases by 4.34%, respectively.

As we know, the decay process of radionuclide can hardly be influenced by external physical and chemical factors. If the conclusion in ref. [3] is truth, the fresh vision for nuclear character will be shown. So it is very necessary for us to select ^{32}P as the object because it can be easily gained.

2 Materials and methods

2.1 ^{32}P samples

^{32}P was produced by $^{31}P(n, \gamma)\ ^{32}P$. 0.23276 g phosphoric acid of analytical pure was sealed in a polyethylene tube and irradiated for 7 h of Miniature Neutron Source Reactor (MNSR) of China Institute of Atomic Energy (CIAE) at a neutron flux of approximately 7×10^{11} $cm^{-2}\cdot s^{-1}$. After cooling for 15 d, the irradiated solution was diluted with distilled water to 2.2034 g. Two aliquots were taken out and weighed into two polyethylene counting vials labeled as A_1 (100.68 mg) and A_2 (49.93 mg) and scintillation fluid (consisting of 500 mL 1,4-dioxane +150 g naphthalene+4 g 2,5-diphenyloxazole (PPO)+0.5 g 1,4-bis-[2-(5-pheny(oxazolyl)-benzene)](POPOP)) was added. Then the two samples were measured by LS6000 liquid scintillation counter (made by BECKMAN Company, USA. Its background counting rate was 30 min^{-1}. The detection efficiency of β radiation of 1710 keV is approximately 100%) and their specific radioactivity is 408.5±0.8 Bq/mg (reference time is 14:06 8/5/2007).

Received March 26, 2008; accepted April 15, 2008
doi: 10.1007/s11426-009-0012-4
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2.2 Experimental

Other nine aliquots were taken out, weighed and sealed into nine polyethylene tubes respectively. The total 11 samples were divided into group A and group B, and their sample weights are shown in Table 1. Group A (A_1, A_2, A_3) were placed under natural conditions (room temperature was 25℃—29℃, relative humidity was 20%—40%). Group B (B_1, B_2, …, B_8) were placed in a Φ 20 cm centrifuge (FeiGe TDL-60B centrifuge made by Shanghai Anting Science Instrument Company) and rotated anticlockwise with a speed of 4000 r/min at the radius of 10 cm. The rotor of centrifuge was exposed in air so as to ensure the temperature and humidity of group B is the same as group A.

Each sample of group B was took out sequentially and counted together with that of group A (A_1, A_3) by LSC after every tens of hours of centrifugal movement. Every operation time was recorded. Every sample was counted for 1 min. For taking out of every group B sample, the break time of rotation was less than 2 min.

Table 1 The grouping of samples

No. of group A	Sample weight (mg)	No. of group B	Sample weight (mg)
A_1	100.68	B_1	111.60
A_2	49.93[1)]	B_2	115.48
A_3	98.50	B_3	116.34
		B_4	115.95
		B_5	116.80
		B_6	104.60
		B_7	103.57
		B_8	70.62

3 Results and discussion

3.1 Reliability

When a radionuclide is detected by LSC, the sample must be mixed with scintillation fluid. It is necessary to study the influence of the contacting time of radionuclide with scintillation fluid on detection efficiency. Scintillation fluid was added into Sample A_1 and A_2, and then they were detected orderly by LSC. The specific activities of A_1 and A_2 were equal within 0.3 percent uncertainty (see Table 2). After 16 days, sample A_3 was added with scintillation fluid and then counted orderly by LSC together with sample A_1. Their specific activities were also found to be equal within 0.3 percent uncertainty. So the counting method is considered to be reliable and its uncertainty of ^{32}P is within 0.6% when the counts per minute are more than 10^5.

Table 2 Stability of scintillation fluid samples

		A_1	A_2	A_3	RSD (%)
Run 1	detection start time	14:06 8/5/2007	13:54 8/5/2007	–	
	counts (min^{-1})	2472910	1221484	–	
	specific activity ($Bq\cdot mg^{-1}$)	409.37	407.57[a)]	–	0.3
Run 2	detection start time	10:08 24/5/2007	–	9:04 24/5/2007	
	counts (min^{-1})	1137936	–	1120495	
	specific activity ($Bq\cdot mg^{-1}$)	188.38	–	189.16[a)]	0.3

a) Specific activity was adjusted to the detection start time of A_1, the half-life is 14.262 d[4].

3.2 The decay of ^{32}P in centrifugal fields and under natural conditions

Place the samples of group B into the centrifuge, and start to rotate at 9:50 22/5/2007. Then certain sample of group B was taken out every other tens of hours and mixed with scintillation fluid and measured orderly with sample A_1 and A_3. The results are listed in Tables 3 and 4.

It can be seen from Tables 3 and 4, after 647 hours, the specific activities of the samples of group B in centrifugal fields are equal to those of samples A_1 and A_3 under natural conditions. This result disagrees with that of ref. [3].

3.3 The half-life of ^{32}P

3.3.1 The half-life of ^{32}P in centrifugal fields. The logarithms of specific activities of samples of group B vs. their rotation time are plotted in Figure 1. The fitting equation of the straight line is $\ln A = (5.3390 \pm 0.0011) - (2.040 \pm 0.0027) \times 10^{-3}\, t$, so $T_{1/2} = (339.78 \pm 0.45)$ h = (14.156 ± 0.019) d.

3.3.2 The half-life of ^{32}P under natural conditions. The logarithms of specific activities of sample A_1 vs.

1) After this paper was published in Science in China Series B: Chemistry (Chinese version) (2008, 38(11): 1035~1037), Prof. He Y J queried the correctness of some data presented. We then carefully checked those data and correct the mistakes in this paper. Thanks go to Prof. He Y J for his queries.

Table 3 The decay of ^{32}P in centrifugal fields

Counting start time	Rotation (h)	Sample No.	Sample weight (mg)	Counts (min^{-1})	Specific activity ($Bq \cdot mg^{-1}$)
9:01 24/5/2007	47.18	B_1	111.60	1266654	189.17
9:09 28/5/2007	143.32	B_2	115.48	1077925	155.57
14:17 1/6/2007	244.45	B_3	116.34	882417	126.41
8:52 4/6/2007	311.03	B_4	115.95	768992	110.53
9:41 8/6/2007	407.85	B_5	116.80	634821	90.59
8:52 11/6/2007	479.03	B_6	104.60	490927	78.22
8:59 15/6/2007	575.15	B_7	103.57	401349	64.59
8:56 18/6/2007	647.10	B_8	70.62	235468	55.57

Table 4 The decay of ^{32}P under natural conditions

Adjusted time	A_1			A_3		
	counting start time	counts (min^{-1})	specific activity[a)] ($Bq \cdot mg^{-1}$)	counting start time	counts (min^{-1})	specific activity[a)] ($Bq \cdot mg^{-1}$)
9:01 24/5/2007	10:08 24/5/2007	1137936	188.80	9:04 24/5/2007	1120495[1)]	189.61
9:09 28/5/2007	9:24 28/5/2007	938215	155.39	9:15 28/5/2007	919542[1)]	155.62
14:17 1/6/2007	14:33 1/6/2007	763487	126.46	14:25 1/6/2007	747444[1)]	126.51
8:52 4/6/2007	9:08 4/6/2007	667663	110.59	9:01 4/6/2007	654197[1)]	110.73
9:41 8/6/2007	9:58 8/6/2007	549039	90.94	9:52 8/6/2007	537023[1)]	90.90
8:52 11/6/2007	9:10 11/6/2007	474602	78.61	9:04 11/6/2007	464221[1)]	78.58
8:59 15/6/2007	9:20 15/6/2007	390564	64.70	9:14 15/6/2007	381468[1)]	64.58
8:56 18/6/2007	9:18 18/6/2007	337679	55.94	9:12 18/6/2007	330348[1)]	55.93

a) Specific activity of group A is adjusted to the counting start time (Column 1) of group B.

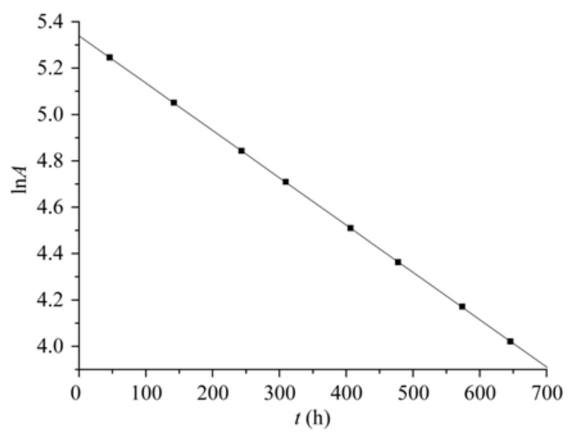

Figure 1 The decay of ^{32}P in centrifugal fields

their rotation time are plotted. The fitting equation of the straight line is $\ln A = (5.3393 \pm 0.0023) - (2.040 \pm 0.0056) \times 10^{-3} t$[1)], so $T_{1/2} = (339.78 \pm 0.93)$ h = (14.156 ± 0.0039) d[1)].

The logarithms of specific activities of sample A_3 vs. its rotation time are plotted. The fitting equation of the straight line is $\ln A = (5.3396 \pm 0.0009) - (2.040 \pm 0.0022) \times 10^{-3} t$, so $T_{1/2} = (339.78 \pm 0.37)$ h = (14.156 ± 0.015) d.

The three values are agreement within 0.6 percent uncertainty. But in ref. [3], the half-life of ^{32}P in centrifugal fields (radius 8 cm, 4000 r/min) is 4.34% more than that obtained under natural conditions.

4 Conclusion

The experimental results indicate that the decay rate of ^{32}P is not changed in anticlockwise rotation motion at 4000 r/min with radius 10 cm.

The authors are thankful to Shu Fujun, Ma Peng, You XinFeng, Hu Yantao, Zhao Yaping, Song Zhijun, Mao Guoshu, Yang Chunli, Yang Jinling, Yang Lei, Liu SuHuan, and Wu Junde for their support of the experiments in Department of Radiochemistry in CIAE, China.

1 Rutherford E, Compton A H. Radio-activity and gravitation. Nature, 1919, 104: 412[DOI]
2 Freed S, Jaffey A, Schultz M. High centrifugal fields and radioactive decay. Phys Rev, 1943, 63: 12－17[DOI]
3 He Y J, Qi F, Qi S C. Changes of decay rates of radioactive ^{111}In and ^{32}P induced by mechanic motion. Sci Chin Ser B: Chem, 2007, 50 (2): 170－174[DOI]
4 Firestone R B, Shirley V S, Table of Isotope 8th CD-ROM Edition, Version 1.0, March, 1996. New York: John Wiley and Sons, 1986

1) See footnote on page 691.