Object: Outgassing measurements of ferrite magnets (part I)

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Ferrite magnets have been suggested for use in the antisprings. We have investigated the behavior of ferrite magnets at different temperatures. The test apparatus and the measurement method are described in detail in the note VACPISA 025. The test apparatus and the measurement method are described in detail in VACPISA025. The outgassing is measured using the dynamic method: measuring both pressures in the sample chamber p_1 and in the pumping chamber p_2 the total outgassing flow can be determined from the relation:

$$Q = (p_1 - p_2) \times C \qquad (1)$$

where C is the conductance (20 l/s N_2 equivalent at 20 ^{0}C) between the chambers. The measurement is performed twice, with and without the sample in the chamber: the difference between the two flow values will represent the net sample outgassing; the difference in the RGA spectra will give the mass distribution of the sample outgassing.

1 - System performances

After baking the base pressure of the chamber is of the order of 10^{-9} mbar and the outgassing rate of the order of 10^{-11} mbar l s^{-1} cm^{-2}. The main components of outgassing are H_2, H_20, N_2/CO, CO_2.

2 - Measurement of the outgassing flow of ferrite magnets

The samples were ferrite magnets (brick shape, 60mmx20mmx15mm) type Ferroxdure 330 produced by Philips.

We cleaned the magnets with alkali soap in ultrasonic bath, rinsing in ultrasonic bath and following baking at 150 ^{0}C in air.

We performed a first test with an exposed surface of 195 cm^2:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
0.5	12	$7.5x10^{-6}$	$1.1x10^{-6}$	$1.3x10^{-4}$
1	12	$3.4x10^{-6}$	$4.2x10^{-7}$	$6.0x10^{-5}$
2	13	$1.6x10^{-6}$	$1.6x10^{-7}$	$2.9x10^{-5}$
2.5	13	$1.3x10^{-6}$	$1.4x10^{-7}$	$2.3x10^{-5}$
67	12	$5.8x10^{-8}$	$6.3x10^{-9}$	$1.0x10^{-6}$
68	12	$6.0x10^{-8}$	$6.2x10^{-9}$	$1.1x10^{-6}$
72.5	20	$1.0x10^{-7}$	$8.8x10^{-9}$	$1.8x10^{-6}$

We performed a second test with more magnets having an exposed surface of 594 cm^2:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
0.25	12	$2.0x10^{-5}$	$2.5x10^{-6}$	$3.5x10^{-4}$
14.5	12	$2.4x10^{-7}$	$1.2x10^{-8}$	$4.6x10^{-6}$
17	12	$4.7x10^{-7}$	$1.7x10^{-8}$	$9.1x10^{-6}$
30	12	$1.0x10^{-7}$	$6.2x10^{-9}$	$1.9x10^{-6}$
32.5	12	$1.1x10^{-7}$	$6.0x10^{-9}$	$2.1x10^{-6}$

The outgassing spectrum measured after 32.5 hours is reported in Fig. 1.

We baked the chamber at 100 ^{0}C:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
during	100	$2.2x10^{-5}$	$2.9x10^{-7}$	$4.3x10^{-4}$

The spectrum measured after 2 hours is shown in Fig. 2, where there is evidence of a strong contamination. During the cooling down we observed:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
during	50	$3.1x10^{-7}$	$1.3x10^{-8}$	$5.9x10^{-6}$

The spectrum measured at 50 ^{0}C is shown in Fig. 3, where there is still some contamination. The time evolution of the outgassing is summarized in Fig. 4.

We prepared a new set of magnets to check if the contamination was coming from the cleaning process or not by using only baking in air at 150 ^{0}C. The exposed surface was 396 cm^2:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
1.5	12	$1.0x10^{-5}$	$3.8x10^{-6}$	$1.2x10^{-4}$
4.5	12	$2.5x10^{-6}$	$2.1x10^{-7}$	$4.6x10^{-5}$
7.5	12	$1.8x10^{-6}$	$1.6x10^{-7}$	$3.3x10^{-5}$
8.5	12	$1.5x10^{-6}$	$1.3x10^{-7}$	$2.7x10^{-5}$
24	12	$3.2x10^{-7}$	$4.0x10^{-8}$	$2.6x10^{-5}$

The outgassing spectrum after 24 h is reported in Fig. 5.

We set temperature at 50 ^{0}C and monitored the evolution of outgassing (time is measured relatively to beginning of heating):

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
4.5	50	1.3×10^{-6}	1.0×10^{-7}	2.4×10^{-5}
6	50	1.0×10^{-6}	8.4×10^{-8}	1.8×10^{-5}
8.5	50	6.9×10^{-7}	6.4×10^{-8}	1.2×10^{-5}
72.5	50	2.5×10^{-7}	5.4×10^{-8}	3.9×10^{-6}
78	50	1.0×10^{-7}	1.4×10^{-8}	1.7×10^{-6}
80.5	50	9.7×10^{-8}	1.3×10^{-8}	1.7×10^{-6}
96	50	6.7×10^{-8}	7.1×10^{-9}	1.2×10^{-6}

The spectrum taken after 96h is reported in Fig. 6. There is evidence of organic contamination.

We set temperature at 100 ^{0}C and monitored the evolution of outgassing:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
0.5	100	6.3×10^{-6}	2.7×10^{-7}	1.2×10^{-4}
1	100	4.5×10^{-6}	2.2×10^{-7}	8.6×10^{-5}
2.25	100	8.3×10^{-6}	4.2×10^{-7}	1.6×10^{-4}
5	100	3.2×10^{-6}	1.9×10^{-7}	6.0×10^{-5}
7	100	1.9×10^{-6}	1.2×10^{-7}	3.0×10^{-5}
9	100	1.5×10^{-6}	9.7×10^{-8}	2.8×10^{-5}
26	100	3.9×10^{-7}	2.6×10^{-8}	7.3×10^{-6}
30	100	3.4×10^{-7}	2.4×10^{-8}	6.3×10^{-6}
48	100	2.3×10^{-7}	1.7×10^{-8}	4.3×10^{-6}

The spectrum taken after 48 hours is reported in Fig. 7, where some organic contamination is evident. We switched off heating and after cooling down we got:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
after	13	2.5×10^{-9}	1.0×10^{-9}	3.0×10^{-8}

The spectrum is shown in Fig. 8. The outgassing rate evolution is summarized in Fig. 9.

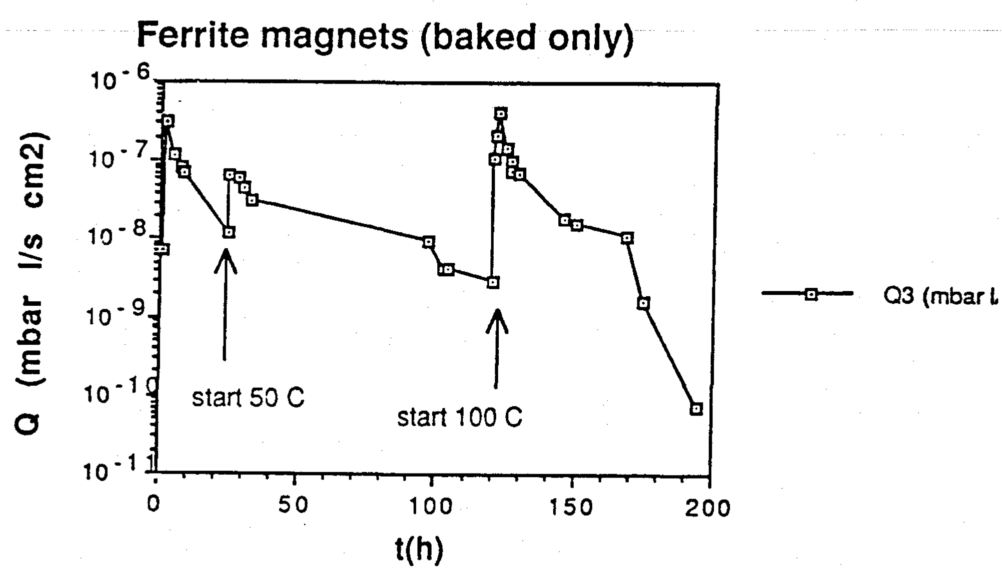
3 - Discussion

We have measured the outgassing of ferrite magnets with two different cleaning methods. The use of soaps should be avoided since they are absorbed in the bulk of material and it is very difficult to pump them out. Simple baking in air seems to be more suitable. The relevant outgassing rates of simply baked ferrite magnets in different conditions are summarized here:

- before baking, 72 hours pumping : 4.4×10^{-8} mbar l s^{-1} cm^{-2}

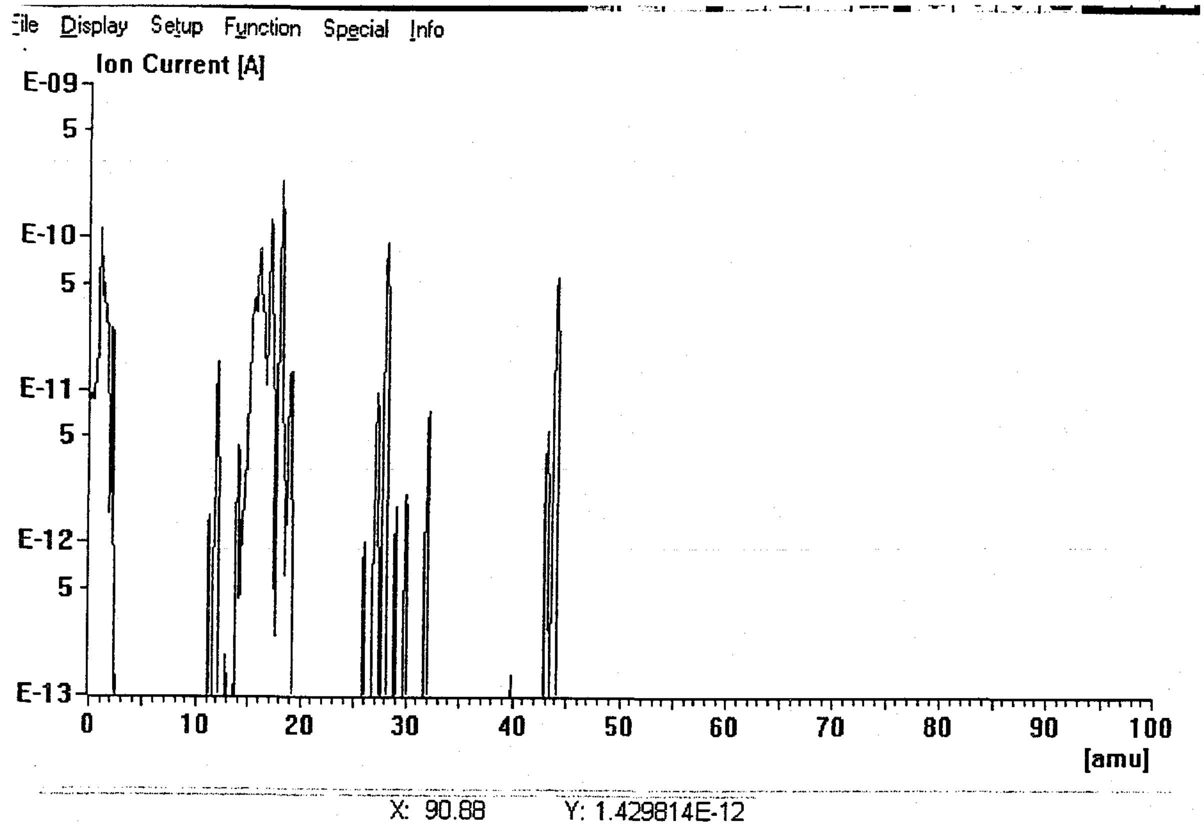
- after baking at 100 ^{0}C : 7.6×10^{-11} mbar l s^{-1} cm^{-2}

The ferrite magnets should be kept at room temperature or below. At higher temperatures there is a strong emission of hydrocarbon fragments. If ferrite magnets are to be used without being sealed, they should not be baked in situ. In the near future we will test again ferrite magnets with alcohol cleaning to check if the vacuum properties can improve. These magnets are not specifically prepared for vacuum but for large scale market: the producer claims that it is not possible to guarantee a more careful preparation and handling. Another concerning point which should be addressed is the dust debris detaching from the magnet body. As explained in detail in a forthcoming note, the antispring magnets turn out to be the most relevant component in the upper part of the tower from the point of view of outgassing. It should be considered the possibility to encapsulate them as often performed in accelerator applications. At the moment we can consider the ferrite magnets as provisionally approved: the outgassing rate is not high but the outgassing composition is not matching VIRGO requirements, the behavior becoming worse with increasing temperatures; on the other hand, at the moment there is not yet a better alternative from the point of view of magnetic stability. Alternative magnets which should exhibit better vacuum properties and minor dust contamination, as required for the vacuum of the lower part of the tower, are Rare-Earth-Magnets (mainly Samarium-Cobalt) which will be tested soon. It should be suitable to study their behavior from the point of view of stability.



Ferrite magnets (baked only)
Q (mbar l/s cm2)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
10⁻¹⁰
10⁻¹¹
0
50
100
150
200
t(h)
start 50 C
start 100 C
Q3 (mbar l

Fig. 9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E-13
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Y: 1.429814E-12

Fig. 1

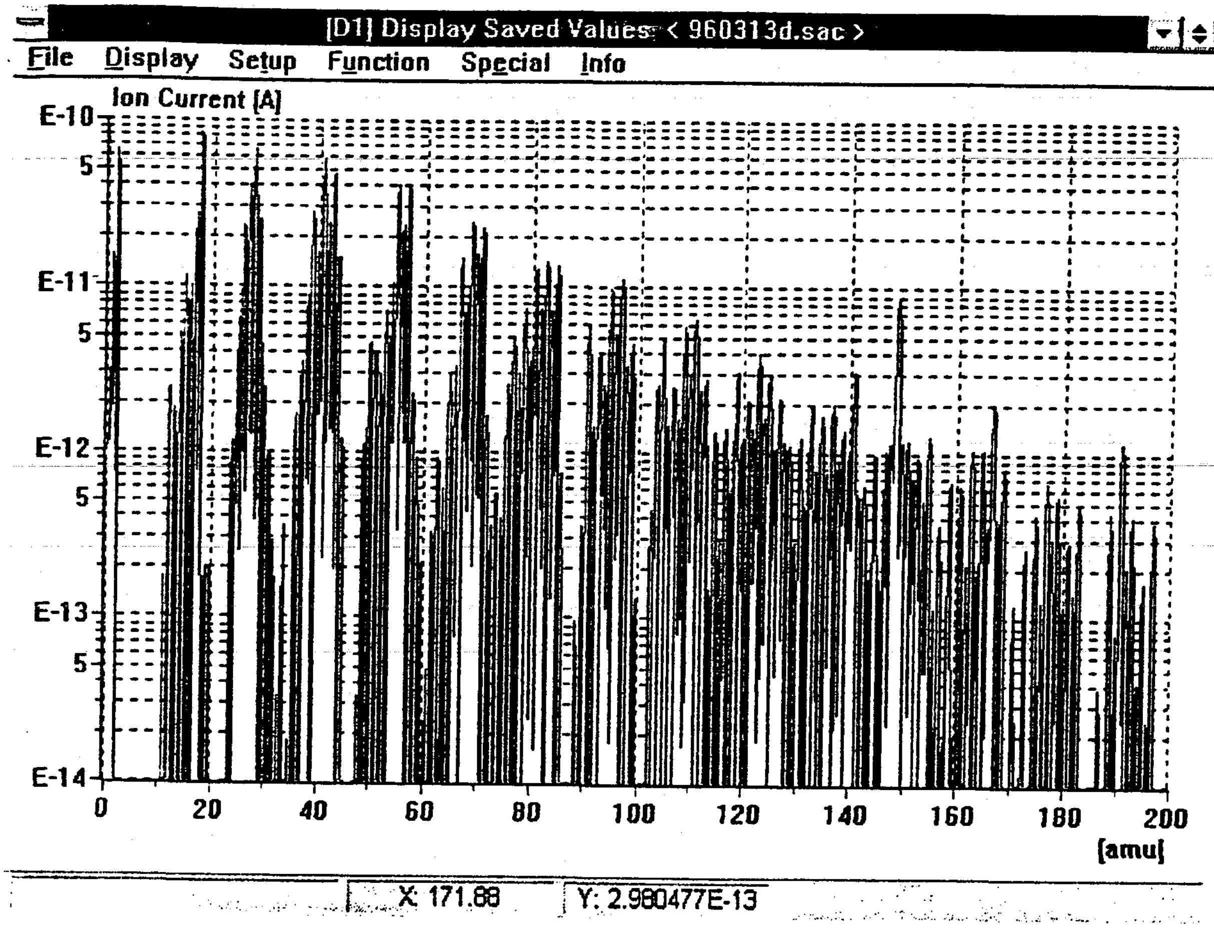
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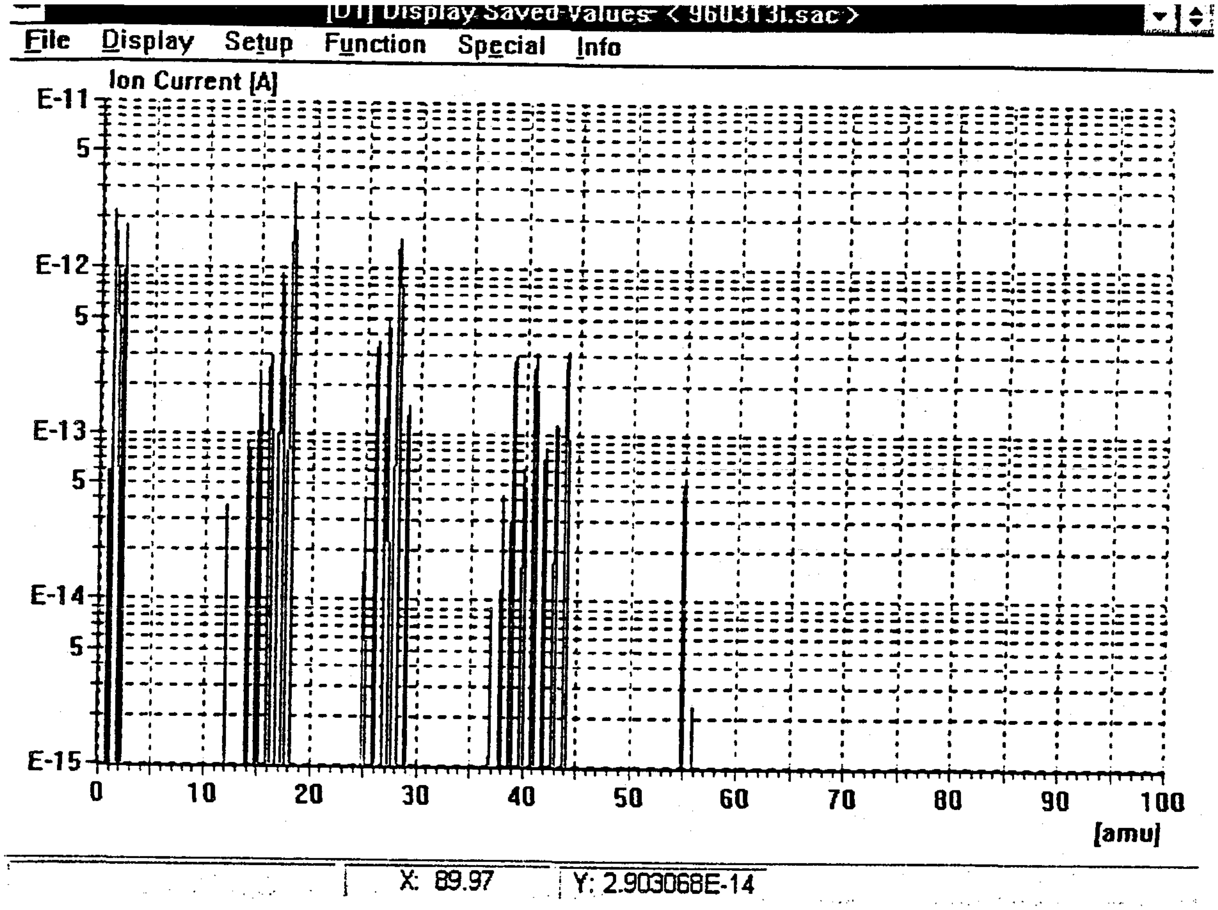
Fig. 2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X: 89.97
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Fig. 3

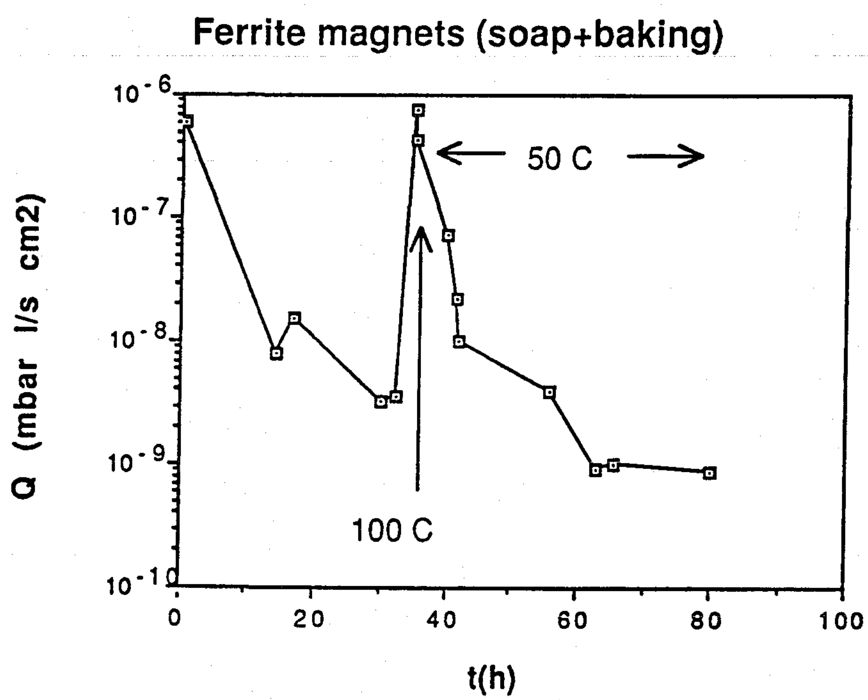
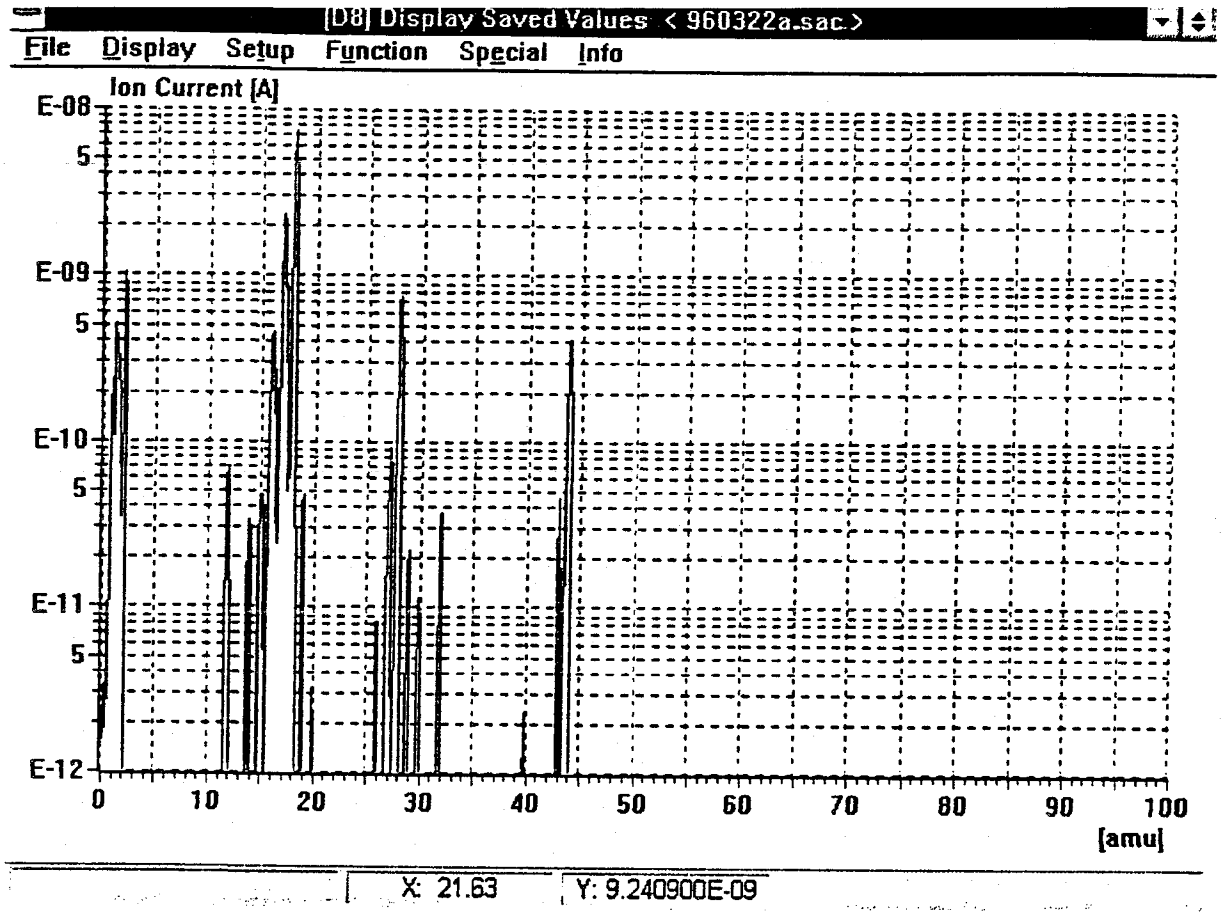

Ferrite magnets (soap+baking)
Q (mbar l/s cm2)
10-6
10-7
10-8
10-9
10-10
0
20
40
60
80
100
t(h)
50 C
100 C

fig. 4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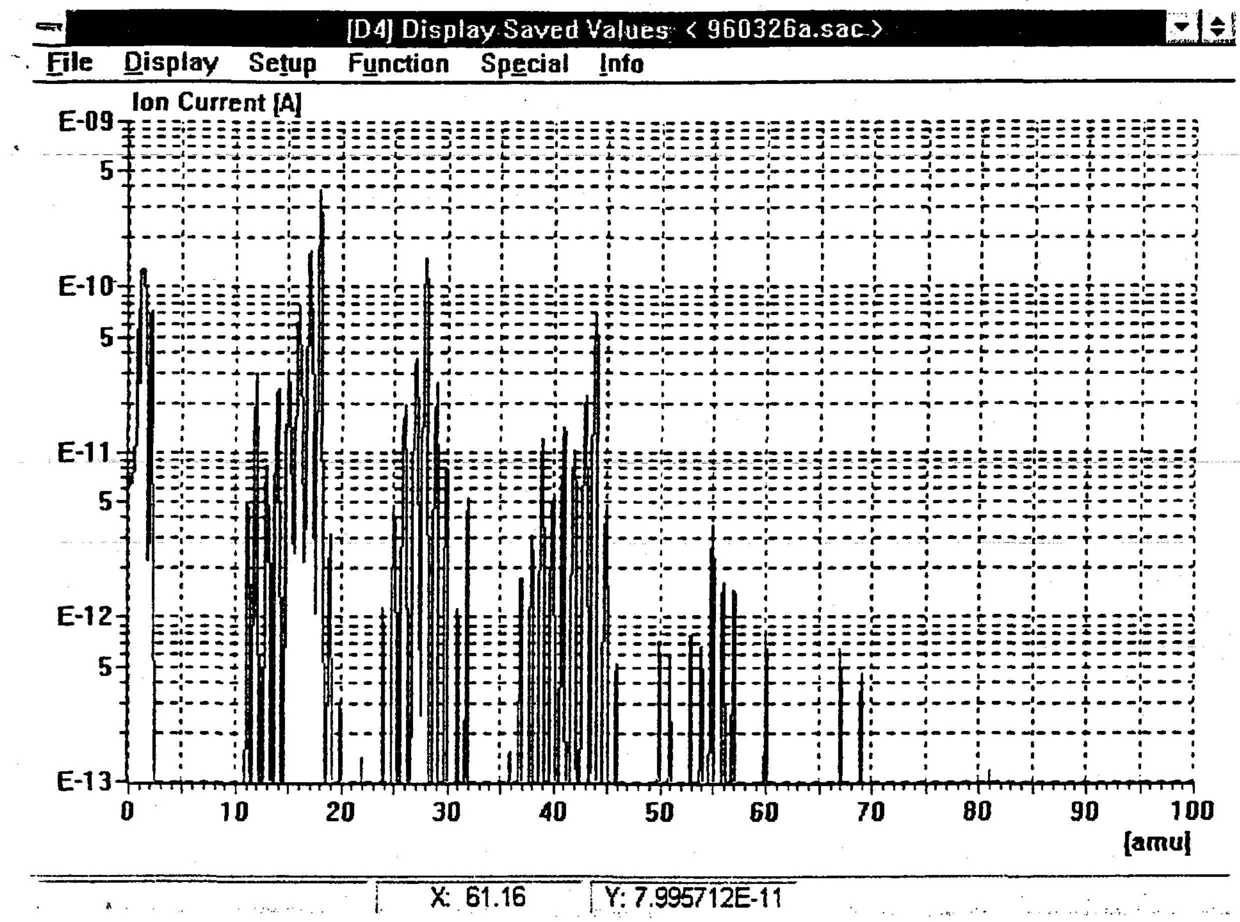
X: 21.63
Y: 9.240900E-09

Fig. 5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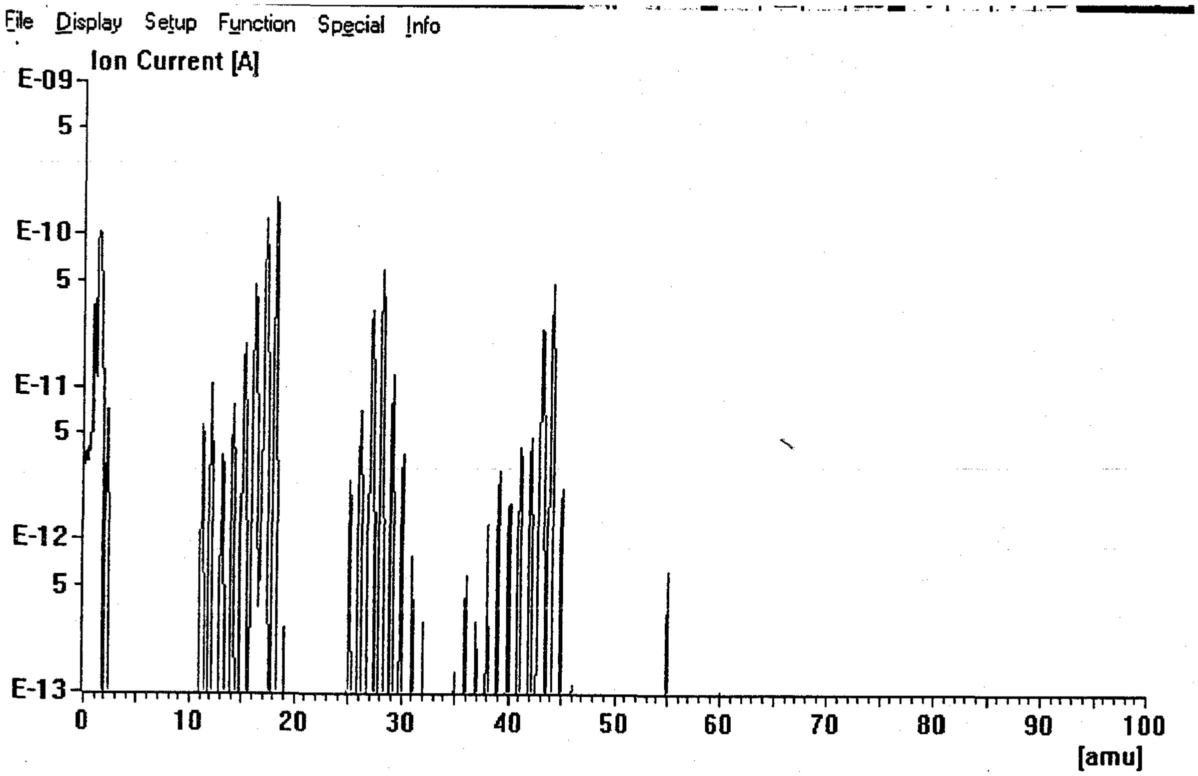
X: 61.16
Y: 7.995712E-11

Fig. 6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90
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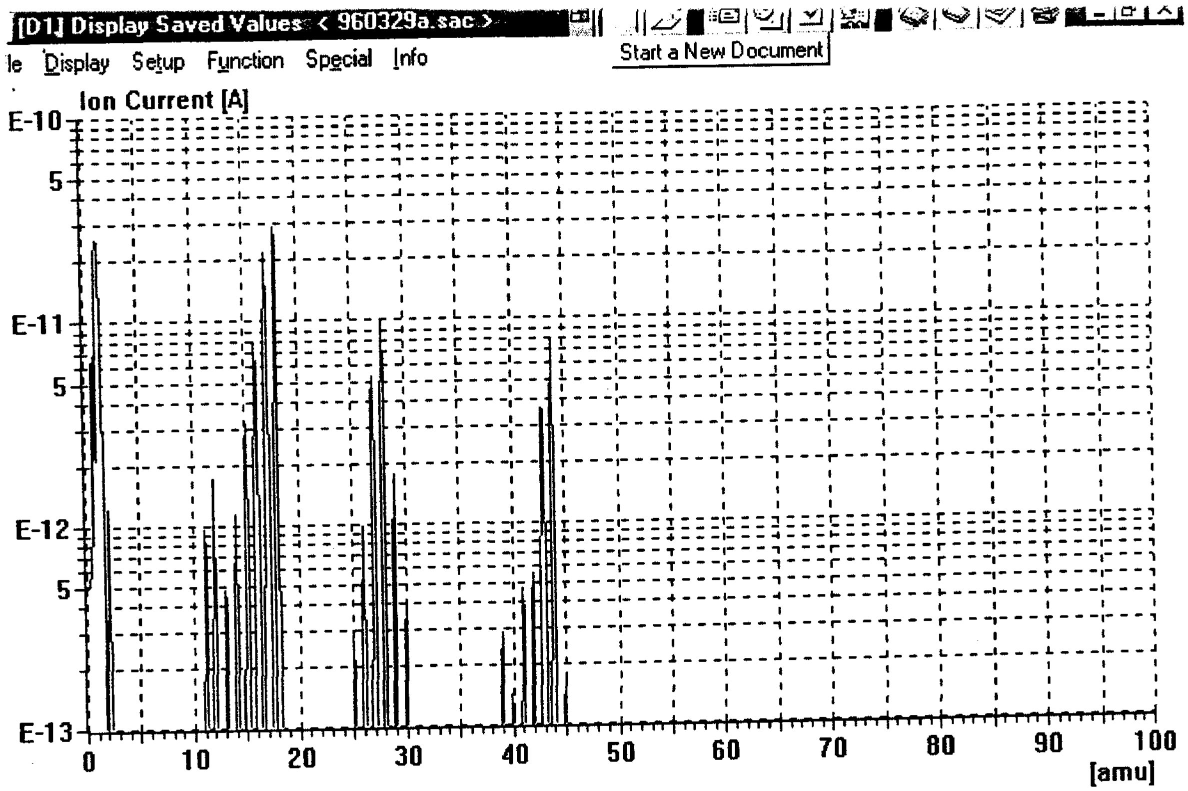
Fig. 7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E-11
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E-12
5
E-13
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10
20
30
40
50
60
70
80
90
100
[amu]

Fig. 8