Object: Outgassing measurements of samarium cobalt magnets

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Magnets are widely used in different parts of VIRGO. Special magnets with low outgassing and low dust contamination are needed in the cleaner vacuum region of the tower. We have investigated the behavior of samarium cobalt magnets at different temperatures including baking at 150 ^{0}C. 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

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

2 - Outgassing properties of samarium cobalt magnets

We tested 19 bricks 36x19x4 mm^3 of samarium cobalt magnets type SmCo2:17 manufactured by Magnet Developments, UK. The surface exposed to vacuum was 316 cm^2. The samples have been cleaned by baking at 150 ^{0}C in air for a few hours. We monitored the outgassing flow evolution (the time as measured from the beginning of the test will be used in the whole paper):

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
0.5	35	5.5×10^{-5}	3.7×10^{-5}	3.6×10^{-4}
1.5	35	1.5×10^{-5}	1.0×10^{-5}	1.0×10^{-4}
3	35	7.2×10^{-6}	4.9×10^{-6}	4.6×10^{-5}
20	35	7.0×10^{-7}	5.2×10^{-7}	3.6×10^{-6}
24	35	2.0×10^{-7}	3.7×10^{-8}	3.3×10^{-6}
43	35	7.6×10^{-8}	1.0×10^{-8}	1.3×10^{-6}
44.5	35	7.0×10^{-8}	9.0×10^{-9}	1.2×10^{-6}

50.5	35	$1.0x10^{-7}$	$1.1x10^{-8}$	$1.8x10^{-6}$

The spectrum taken after 50.5 hours is shown in Fig. 1. We set the temperature to 50 ^{0}C for 20 hours and monitored the evolution of outgassing flow:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
51	50	$9.3x10^{-7}$	$7.7x10^{-8}$	$1.7x10^{-5}$
71	50	$2.9x10^{-7}$	$2.5x10^{-8}$	$5.3x10^{-6}$

The spectrum taken after 20 hours at 50 ^{0}C is shown in Fig. 2: there is some hydrocarbon fragment contamination. We set the temperature to 80 ^{0}C for 40 hours and monitored the evolution of outgassing flow:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
115	80	$1.9x10^{-7}$	$1.3x10^{-8}$	$3.5x10^{-6}$
116	80	$2.3x10^{-7}$	$2.0x10^{-8}$	$4.2x10^{-6}$
121	80	$1.7x10^{-7}$	$2.1x10^{-8}$	$3.0x10^{-6}$

After 40 hours we measured the spectrum in Fig. 3. We set the temperature to 100 ^{0}C for 46 hours and monitored the evolution of outgassing flow:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
122	100	$8.4x10^{-7}$	$5.2x10^{-8}$	$1.6x10^{-5}$
138	100	$5.5x10^{-7}$	$4.0x10^{-8}$	$1.0x10^{-5}$
140.5	100	$5.1x10^{-7}$	$3.6x10^{-8}$	$9.5x10^{-6}$
144	100	$4.6x10^{-7}$	$3.4x10^{-8}$	$8.5x10^{-6}$
164	100	$2.5x10^{-7}$	$2.0x10^{-8}$	$4.6x10^{-6}$
167.5	100	$2.2x10^{-7}$	$1.8x10^{-8}$	$4.0x10^{-6}$

The spectrum taken at 100 ^{0}C is shown in Fig. 4. We set the temperature to 150 ^{0}C for 115 hours and monitored the evolution of outgassing flow:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
169.5	150	$3.1x10^{-5}$	$9.9x10^{-7}$	$6.0x10^{-4}$
171	150	$1.5x10^{-5}$	$5.0x10^{-6}$	$2.9x10^{-4}$
186	150	$1.4x10^{-6}$	$9.1x10^{-8}$	$2.6x10^{-5}$
189	150	$1.2x10^{-6}$	$7.9x10^{-8}$	$2.2x10^{-5}$
193	150	$1.0x10^{-6}$	$6.4x10^{-8}$	$1.9x10^{-5}$
210	150	$5.5x10^{-7}$	$4.1x10^{-8}$	$1.0x10^{-5}$
213	150	$7.5x10^{-7}$	$5.3x10^{-8}$	$8.7x10^{-6}$
218	150	$4.6x10^{-7}$	$3.4x10^{-8}$	$8.5x10^{-6}$
283	150	$1.8x10^{-7}$	$1.6x10^{-8}$	$3.3x10^{-6}$

We switched off the heating and monitored the evolution of outgassing flow:

t(h)	T(^{0}C)	p_1(mbar)	p_2(mbar)	Q(mbar l/s)
289	85	$2.8x10^{-8}$	$5.3x10^{-9}$	$4.5x10^{-7}$

290.5	53	$1.1x10^{-8}$	$2.9x10^{-9}$	$1.6x10^{-7}$
306.5	35	$1.6x10^{-9}$	$7.0x10^{-10}$	$1.8x10^{-8}$
309.5	35	$1.8x10^{-9}$	$7.2x10^{-10}$	$2.2x10^{-8}$
312.5	35	$3.9x10^{-9}$	$9.6x10^{-10}$	$5.9x10^{-8}$
330.5	35	$2.8x10^{-9}$	$8.8x10^{-10}$	$3.8x10^{-8}$
336.5	35	$1.6x10^{-9}$	$5.9x10^{-10}$	$2.0x10^{-8}$
355.5	35	$2.4x10^{-9}$	$7.9x10^{-10}$	$3.2x10^{-8}$
379	35	$2.6x10^{-9}$	$1.2x10^{-9}$	$2.8x10^{-8}$
402.5	35	$2.0x10^{-9}$	$7.6x10^{-10}$	$2.5x10^{-8}$

The spectrum taken after 402.5 hours is shown in Fig. 6.

We have summarized the evolution of the outgassing rate is Fig. 7.

3 - Conclusions

The samarium cobalt magnets achieved a final outgassing rate of $7.9x10^{-11}$ mbar l/(s cm^2) after baking. The outgassing composition at room temperature is quite good. The samarium cobalt magnets can be recommended for use in VIRGO. Comparing with ferrite magnets described in VACPISA 046 we find that the at room temperature the performances are comparable, reminding that room temperature was around 15 ^{0}C for ferrites and 35 ^{0}C for samarium cobalt. On the other hand, the samarium cobalt magnets are much more clean at higher temperatures. At a visual inspection, samarium cobalt magnets appear less porous and with negligible dust detachment as compared to ferrites.

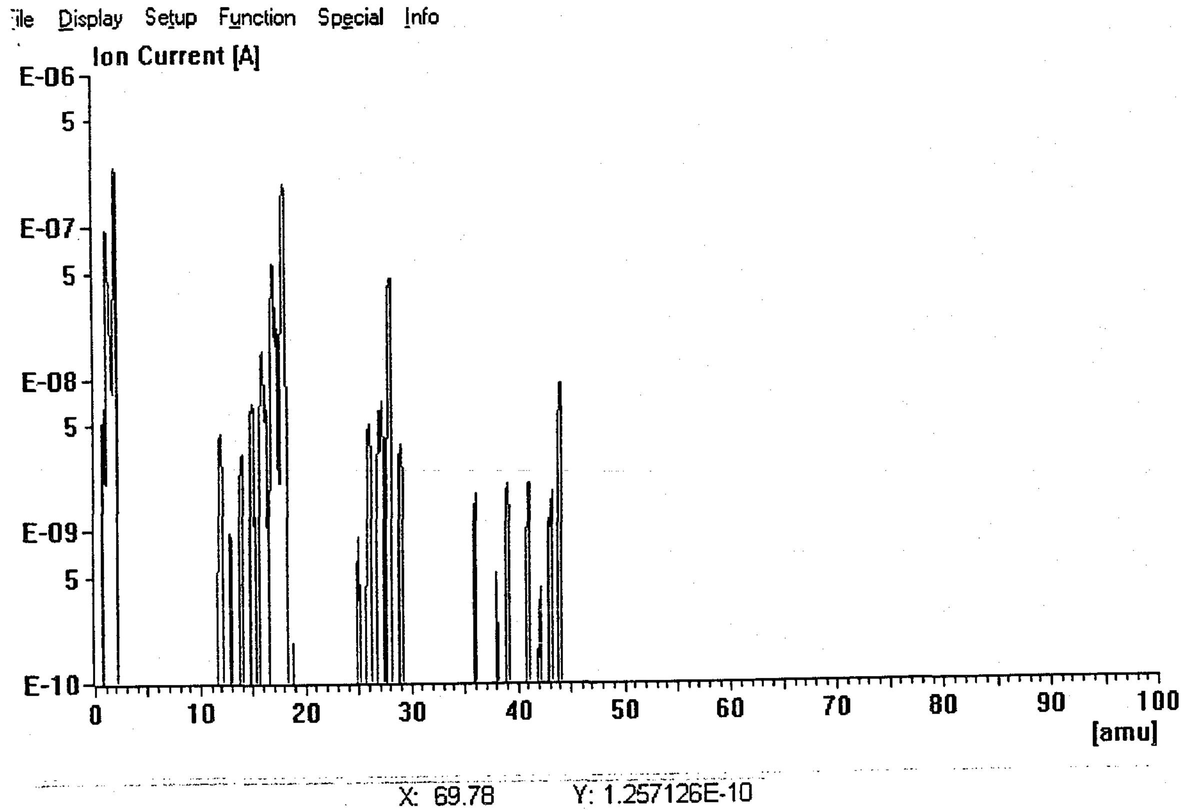
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Fig. 1

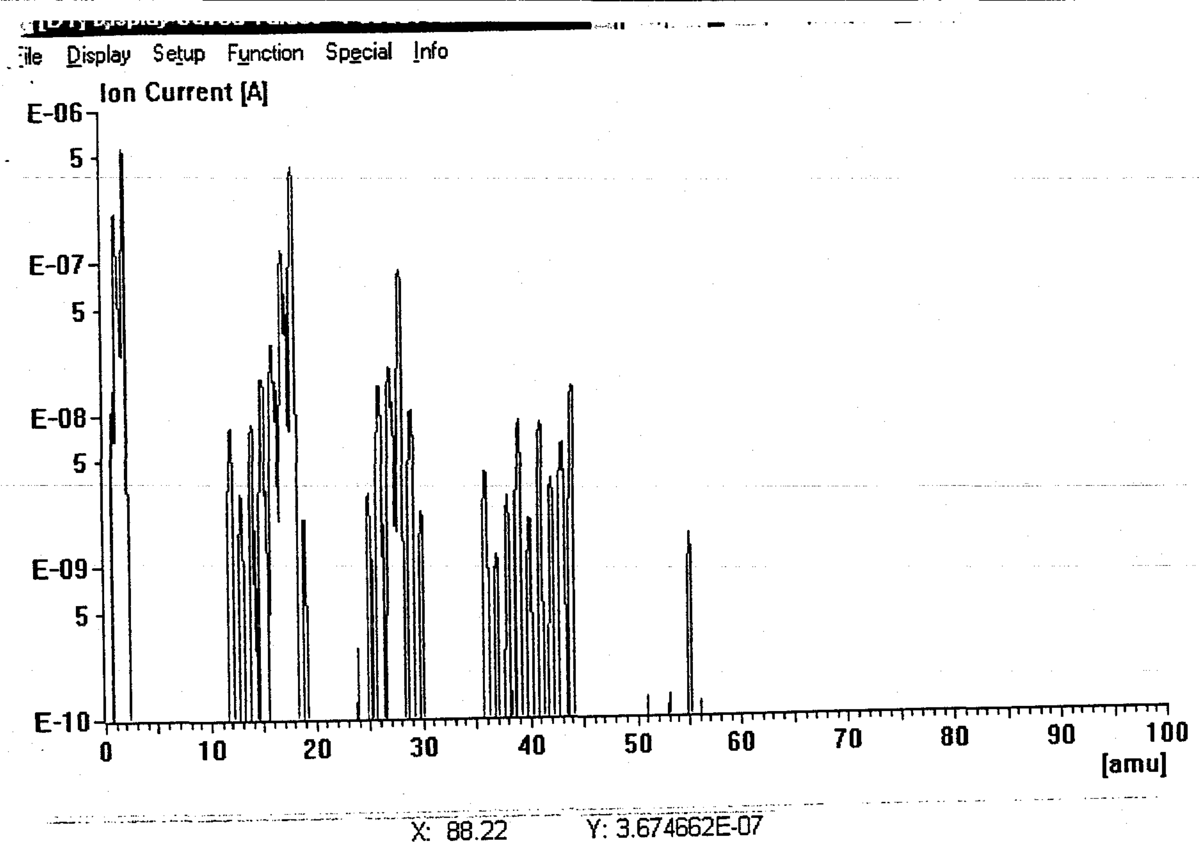
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Fig. 2

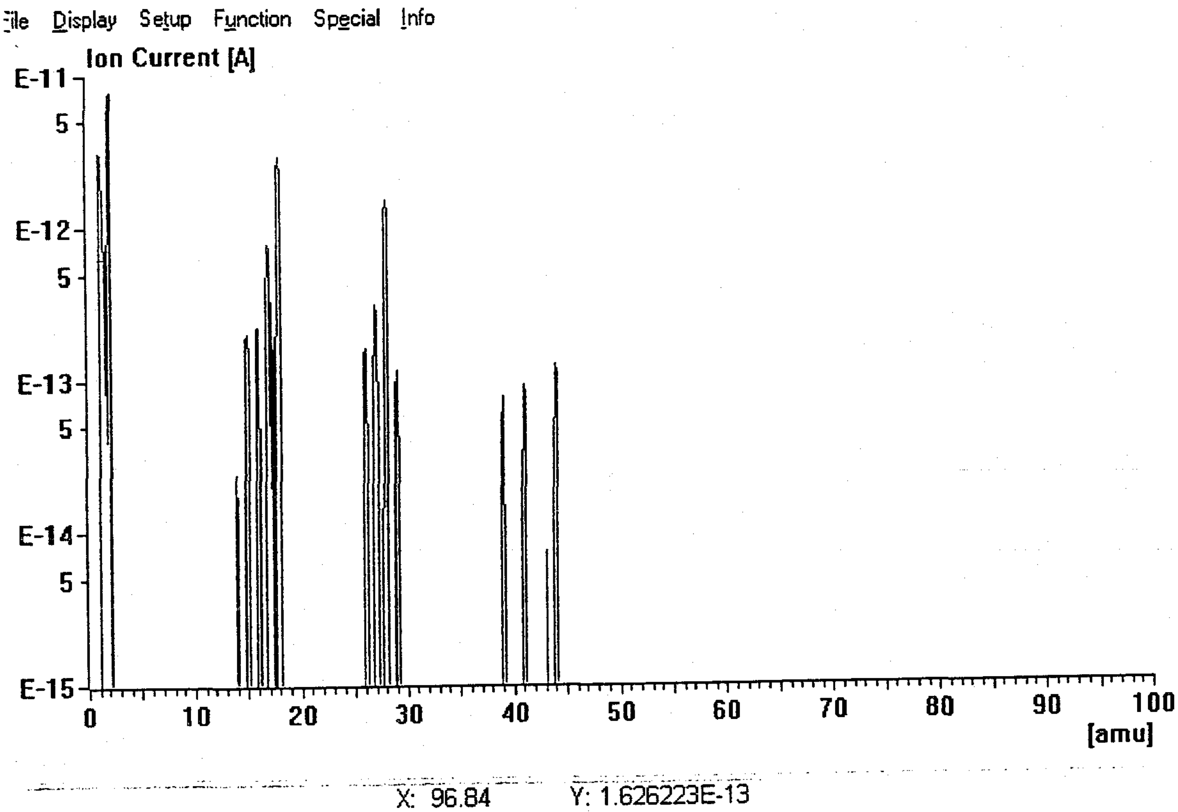
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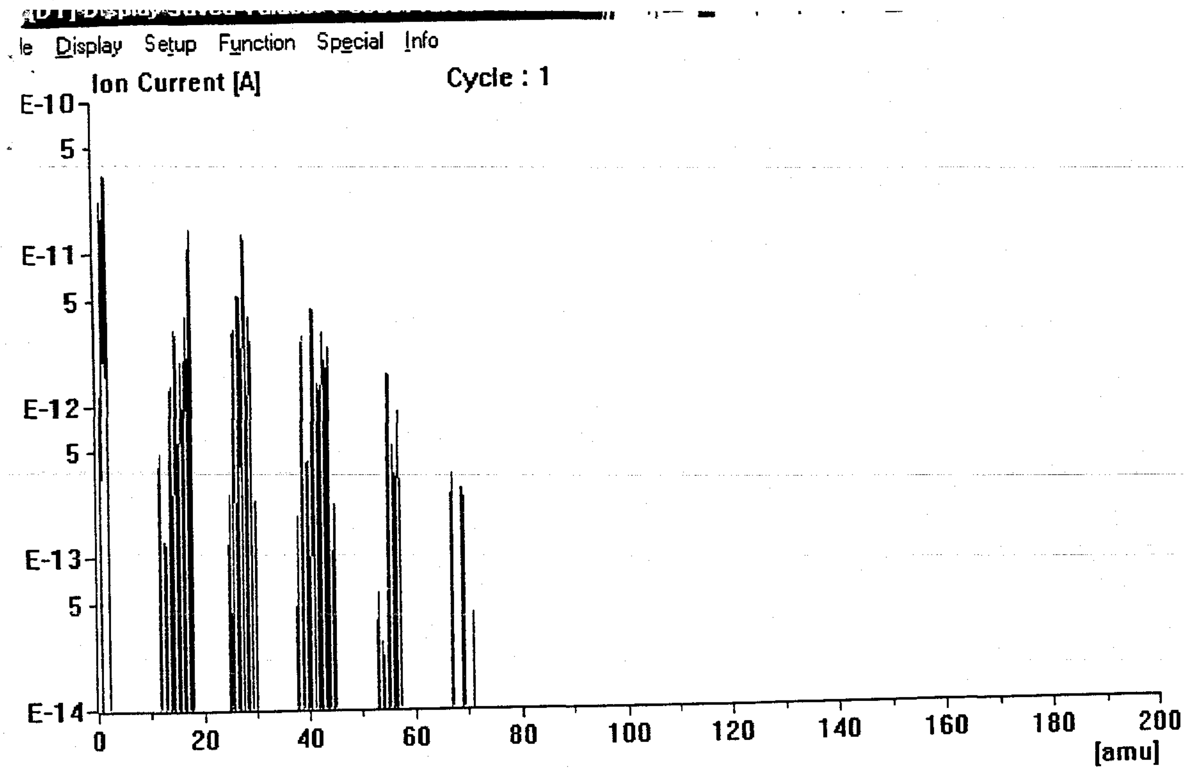
Fig. 2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E-12
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200
[amu]

Fig 4

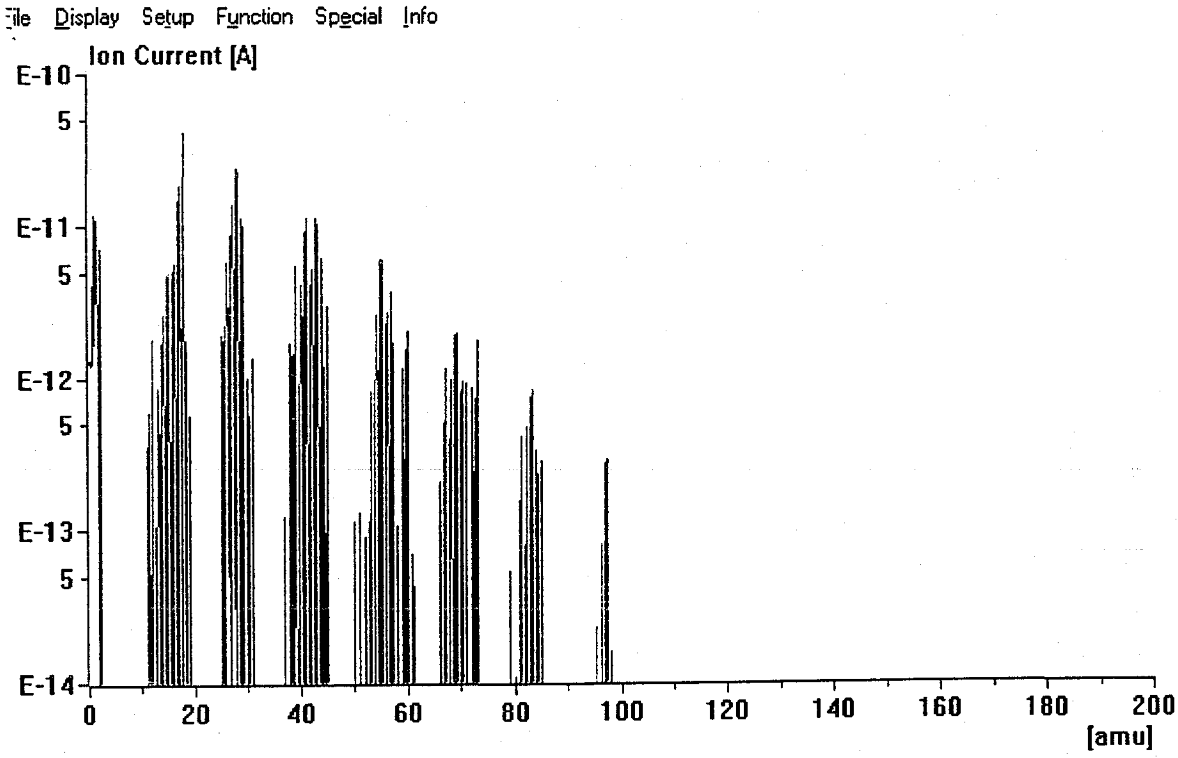
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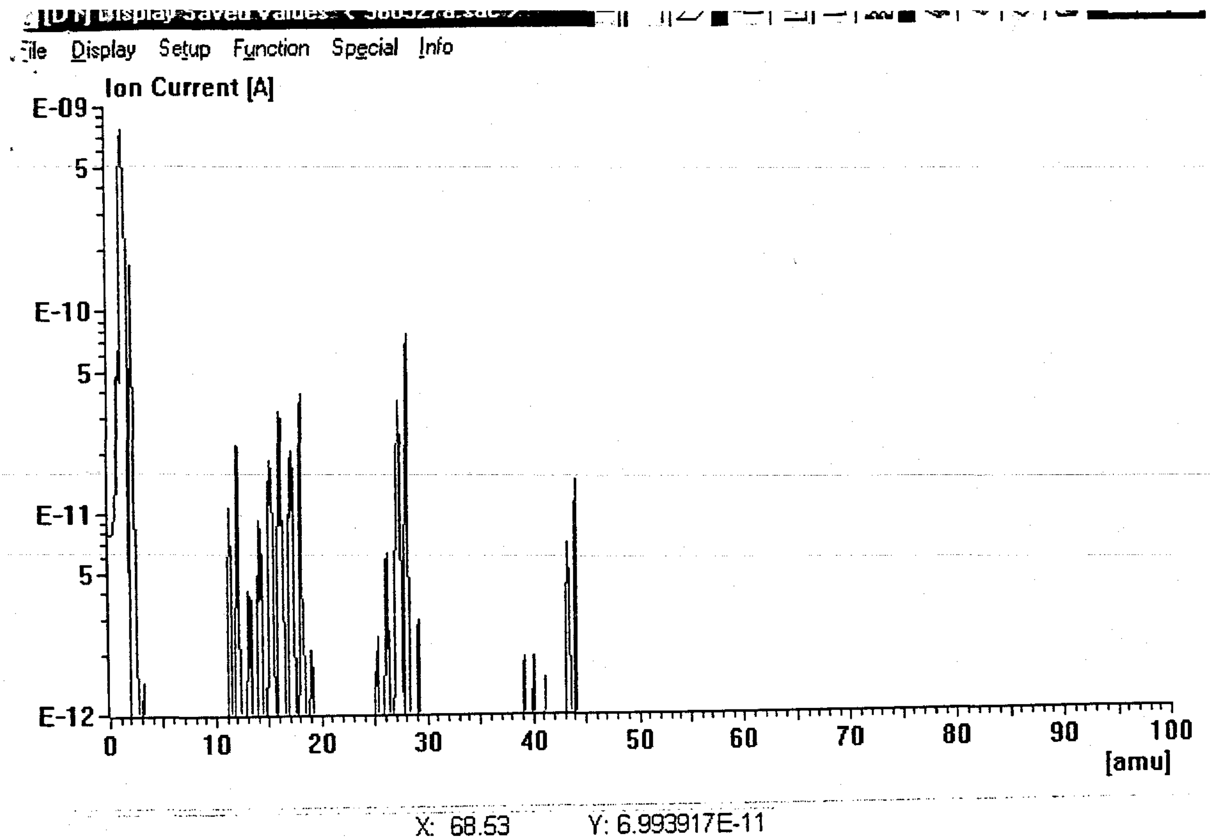
Fig. 5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X: 68.53
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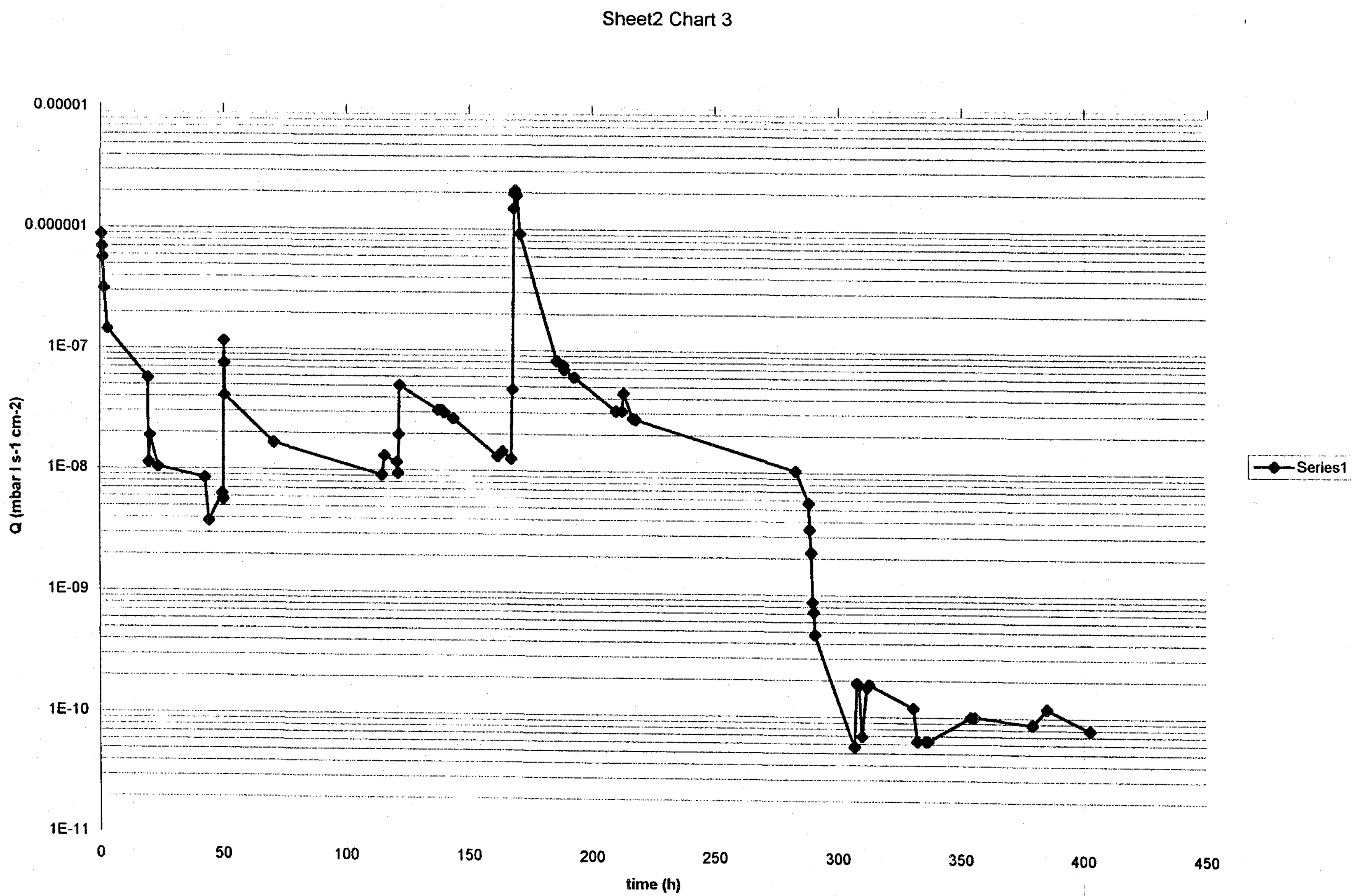
Fig. 10



Sheet2 Chart 3
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1E-08
1E-09
1E-10
1E-11
Q (mbar l s-1 cm-2)
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50
100
150
200
250
300
350
400
450
time (h)
Series1