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Sorption of Antimony on Human Teeth

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The study of the uptake of toxic elements on human teeth represents an interesting research area, as the fate of these elements when present in the human food is of health significance. Since antimony is one of the common toxic elements and since, the chemical behaviour of antimony is similar to that of arsenic, one of the most important toxic elements commonly encountered in cases of food poisoning, it has been decided to investigate its uptake on human teeth and on other restoration materials. The radioactive tracer technique was used to evaluate the concentration of antimony sorbed on teeth. This tracer was obtained by irradiation of antimony metal in the reactor, subsequent dissolution in concentrated sulphuric acid, evaporation to dryness and making the solution 6 M in hydrochloric acid (1). Antimony prepared in this way is in the trivalent state (Sb III). Sorption was studied in water, tea, coffee, red tea and chicken soup. The highest sorption was achieved from water and chicken soup and least sorption was noticed in case of coffee. The results are presented in the form of the depletion of the radioactivity (A) of antimony with time in presence of a tooth in water and other drinks. The percent uptake, U%, given by the relation:

$$U(\%) = \frac{A_0 - A}{A_0} \; 100 ,$$

was also plotted versus the time elapsed.
The kinetics of antimony sorption was discussed in view of the obtained results.

Experimental

Instrument

Scintillation counter. A single channel analyser, with well crystal NaI(T1) type, was used for counting the gross gamma activity of ^{124}Sb ($E\gamma$= 0.61 and 1.69 MeV). The count rates were corrected for the decay time.

Radioactive Stock Solution

Radioactive antimony was produced by the irradiation of metallic antimony (about 50 mg) of high purity in the Egyptian RR-1-2MW Research Reactor at Inshas for 48 hr. Irradiated antimony was then dissolved by heating with a small amount of concentrated sulphuric acid till dissolution was complete, the solution heated to fumes and eventually diluted with 6 M hydrochloric acid. Under these conditions antimony is in the trivalent state and it behaves chemically like trivalent arsenic. Sorption studies were started about one month after end of irradiation when the short-lived ^{122}Sb ($T_{1/2}$= 2.8 d) has decayed and only ^{124}Sb ($T_{1/2}$=60 d), was counted.

Sorption Experiments

To study the sorption of antimony on teeth and other restorative materials, two equal portions (5-ml each) of the liquid under investigation, which has been spiked with a suitable amount of the radioactive antimony tracer, were transfered to two similar 20-ml plastic vilals supplied with covers. An extracted tooth or a piece of restorative material was then transferred to one of the two vials. One-ml aliquot was taken from each vial by an automatic pipette into a test tube at various periods of time, counted for its radioactivity and then returned back to the respective vial. The vials were tightly covered between the readings to minimize liquid losses due to evaporation. The counting was continued during the first working day and was repeated few times on the next day. Each experiment was done in duplicate and the average value was evaluated.

Results and Discussion

Sorption of Antimony

The results on the effect of time on the sorption of antimony on tooth from drinking water (tap water) are demonstrated in Fig.1 in terms of percent uptake, U%. The uptake of antimony by the tooth is seen to rise rapidly with immersion time during the first 3 hours, reaches about 60% of the initial amount and then remains almost unchanged during the second working day.

In Fig.2 are shown the results on the depletion of the antimony radioactivity in water, with the elapse of time, in presence of the tooth, compared to its corresponding level in absence of the tooth, to account for any adsorption of antimony that might take place on the inner walls of the vials. The presence of the tooth causes clear depletion of the antimony content of water, implying that teeth act as a natural filter holding this toxic element and most propably also arsenic; during teeth cleaning by tooth paste and brush elimination of metallic residues can thus be fulfilled.

If water is replaced by chicken soup (chicken stock, fine foods), a rather similar picture is obtained as is clear from the plots of % uptake-time (Fig.3) and counting rate of the liquid-time (Fig.4). From the latter figure a slight sorption of antimony on the walls of the container is noticed, but the sorption is much more considerable in the presence of the tooth.

Figs. 5, 6 and 7 demonstrate the results for tea with and without sugar. As is clear from Fig.5, the effect of adding sugar to the tea has only a small effect on the sorption of antimony on tooth. On the other hand the presence of sugar leads to an increased sorption on the walls of the vial (compare Figs 6 and 7).

The results of antimony sorption on tooth from red tea in absence and presence of sugar are demonstrated in Fig.8. It is clear that the presence of sugar leads to a remarkable rise of antimony sorption on the tooth. Actually this drink is normally used with sugar to make its taste acceptable to the man. Figs. 9 and 10 show the depletion of the radio-activity in red tea with and without sugar, respectively. Contrary to the case of normal tea (Figs.6 and 7), the sorption of antimony on the walls of the vial is higher in absence of sugar. The experiments with coffee showed different results compared to all other studied drinks. Only slight uptake of antimony radioactivity is noticed for coffee without sugar in presence of the tooth indicating a parallel antimony sorption on the tooth, while almost no antimony uptake occurs on the tooth from coffee with sugar (Fig.11).

Fig.12, on the other hand, shows the results for the depletion of the radioactivity of antimony in tap water in the absence and presence of an artificial tooth made of porcelain, which is now in common use as a restorative material. It is clear that the depletion of antimony activity here is remarkably less than in case of the natural tooth, i.e. more antimony sorption takes place on the normal tooth.

Desorption of Antimony

The results on counting each tooth at the end of the sorption experiment before and after washing with tap water are given in Table I Washing was achieved through vigorous rinsing with water for about 3 minutes.

Table 1. Activity of teeth at the end of the sorption experiments with radioantimony before and after washing with tap water (counts/minute)

liquid in the sorption experiment	counting rate before washing	counting rate after washing
tap water	176985	174098
tap water (porcelain)	55927	55233
chicken soup (shicken stook, fine food)	220462	215499
tea with sugar	17840	16724
tea without sugar	17434	15148
red tea with sugar	84692	75640
red tea without sugar	43664	41285
coffee with sugar	12481	11137
coffee without sugar	10627	9033

It is clear that most of the activity remains unwashed from the tooth. For the sake of comparison an artificial tooth made of porcelain and taken from a sorption experiment with tap water, was also counted before and after vigorous rinsing with tap water and the results are given in the same table. Although the amount of radioantimony held by the porcelain tooth is much less than that held by the natural tooth, it is much higher than in case of radiozinc (2). The amount of antimony species held by the natural teeth decreases in the order chicken soup >tap water >red tea >normal tea >coffee. It is to be noted that antimony belongs to the fifth group in the p-block of the periodic table of the elements and is thereby resembling phosphorus belonging to the same group. The two elements may be to some extent isomorphic with each other and this might explain the high sorption of antimony on natural teeth made mainly of hydroxyapatite $Ca_{10}(PO_4)_6(OH)_2$.

Although the uptake-time plots of antimony on teeth seem to be a first order process, the log % uptake-time relationships did not give straight lines within the whole time interval investigated. This might be explained to be the result of partial diffusion of sorbed antimony through the inside structure of the tooth. This view is supported by the difficult desorption of antimony as is clear from the data in Table 1.

References

1- A. Alian, W. Sanad, Extraction and Separation of Sb(III) and Sb(V) by Tertiary Amines, Talanta, 14, 659 (1967).

2- A. Helal, Hewaida Amin, Ghada Alian, Sorption of zinc on Human Teeth, Internal Report, Hot Laboratories Centre, Atomic Energy Authority, Cairo, Egypt, (1997).

Figure Captions

Fig.1. Effect of time on the uptake of antimony on a tooth from water

Fig.2. Depletion of antimony activity in water in presence of a tooth.

Fig.3. Effect of time on the uptake of antimony on tooth from chicken soup.

Fig.4. Depletion of antimony activity in chicken soup in presence of a tooth.

Fig.5. Effect of time on the uptake of antimony on a tooth from tea.

Fig.6. Depletion of antimony activity in tea with sugar in presence of a tooth.

Fig.7. Depletion of antimony activity in tea without sugar in presence of a tooth.

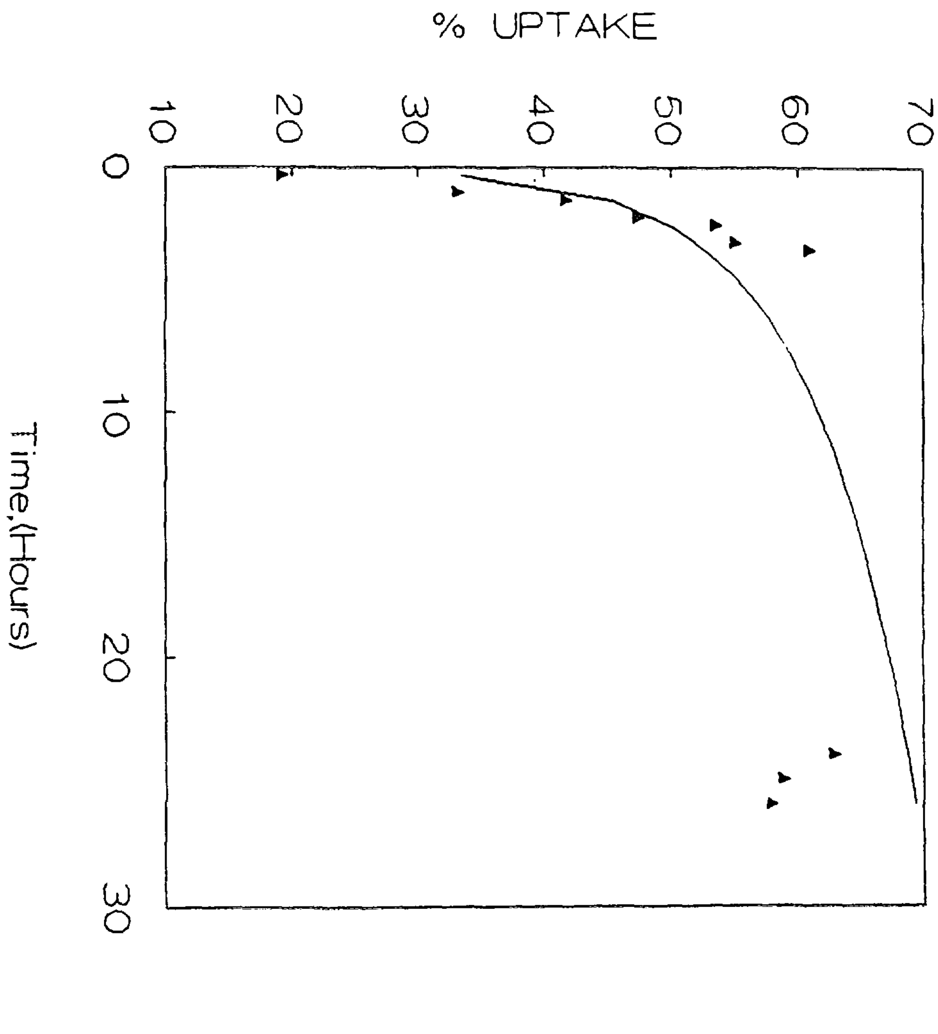
Fig.8. Effect of time on the uptake of antimony on a tooth from red tea.

Fig.9. Depletion of antimony activity in red tea with sugar in presence of a tooth.

Fig.10. Depletion of antimony activity in red tea without sugar in presence of a tooth.

Fig.11. Effect of time on the uptake of antimony on a tooth from soluble coffee.

Fig.12. Depletion of antimony activity in tap water in presence of a porcelain tooth.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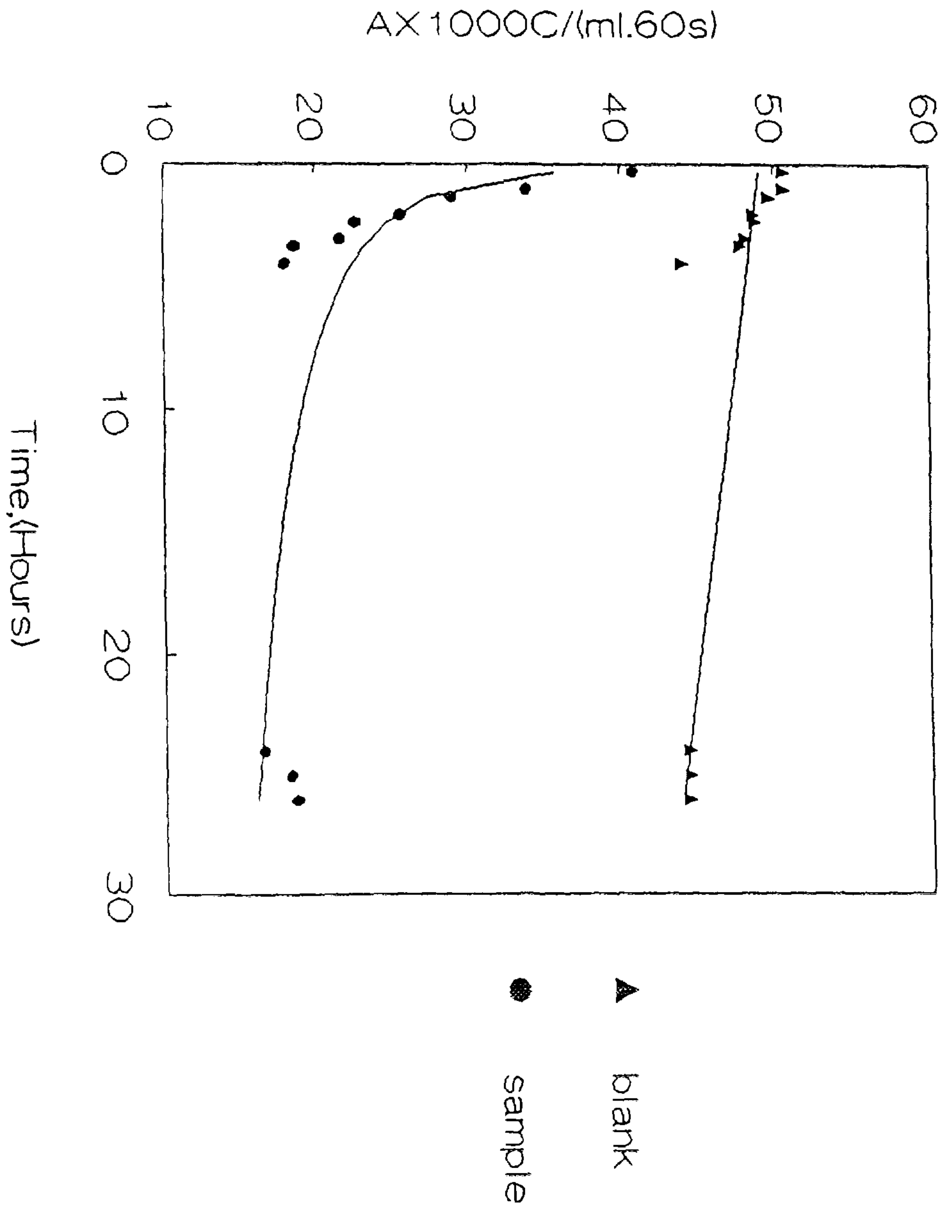
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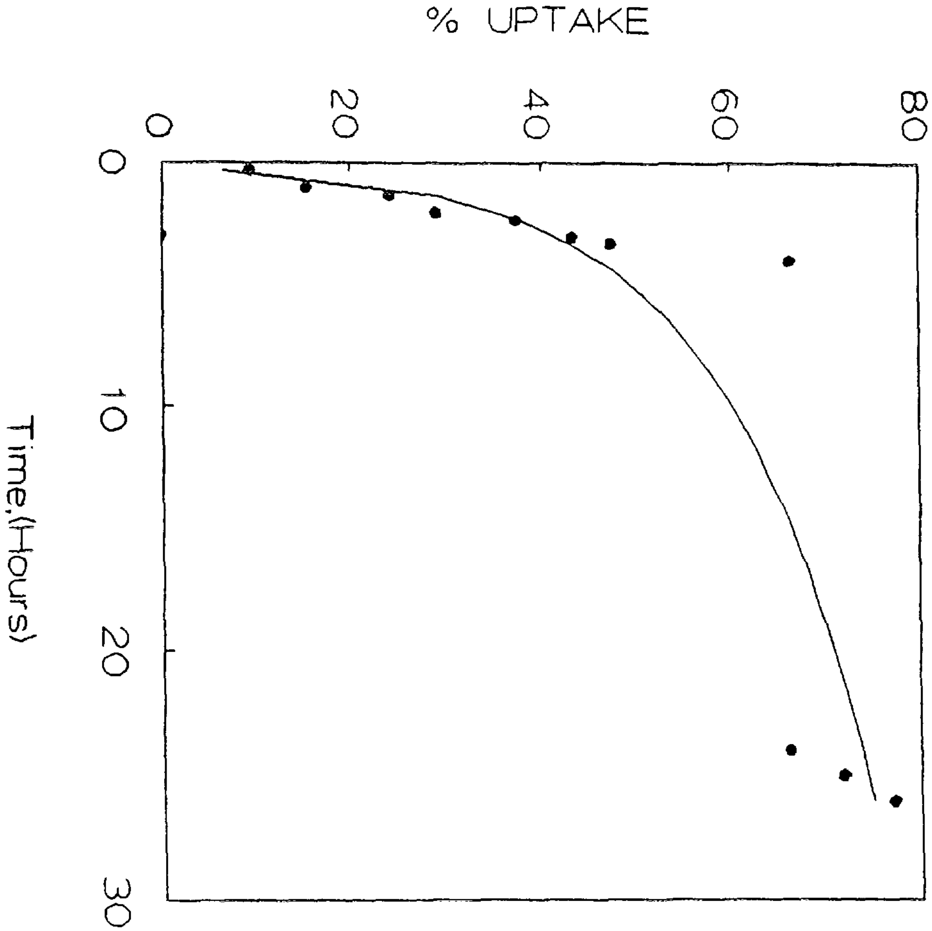
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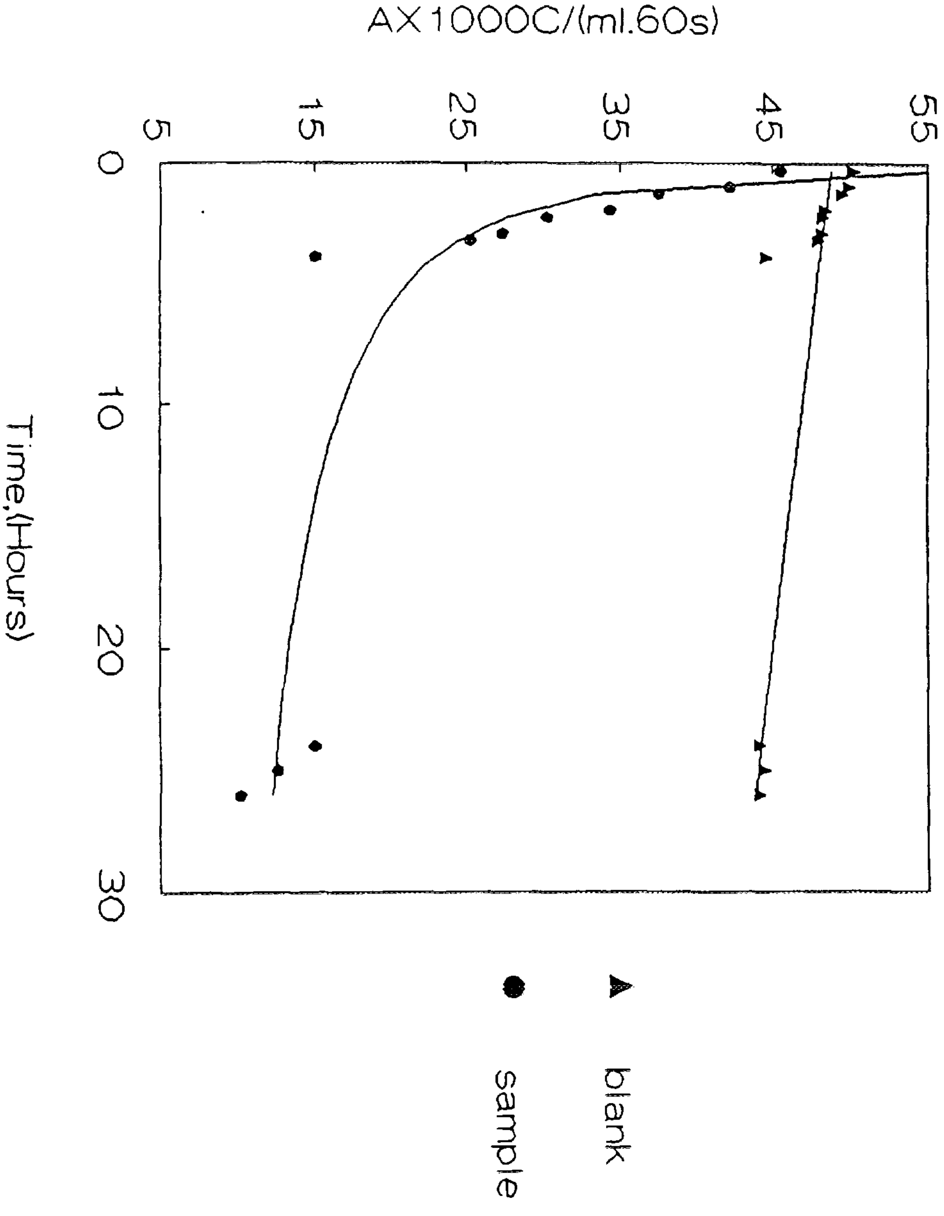

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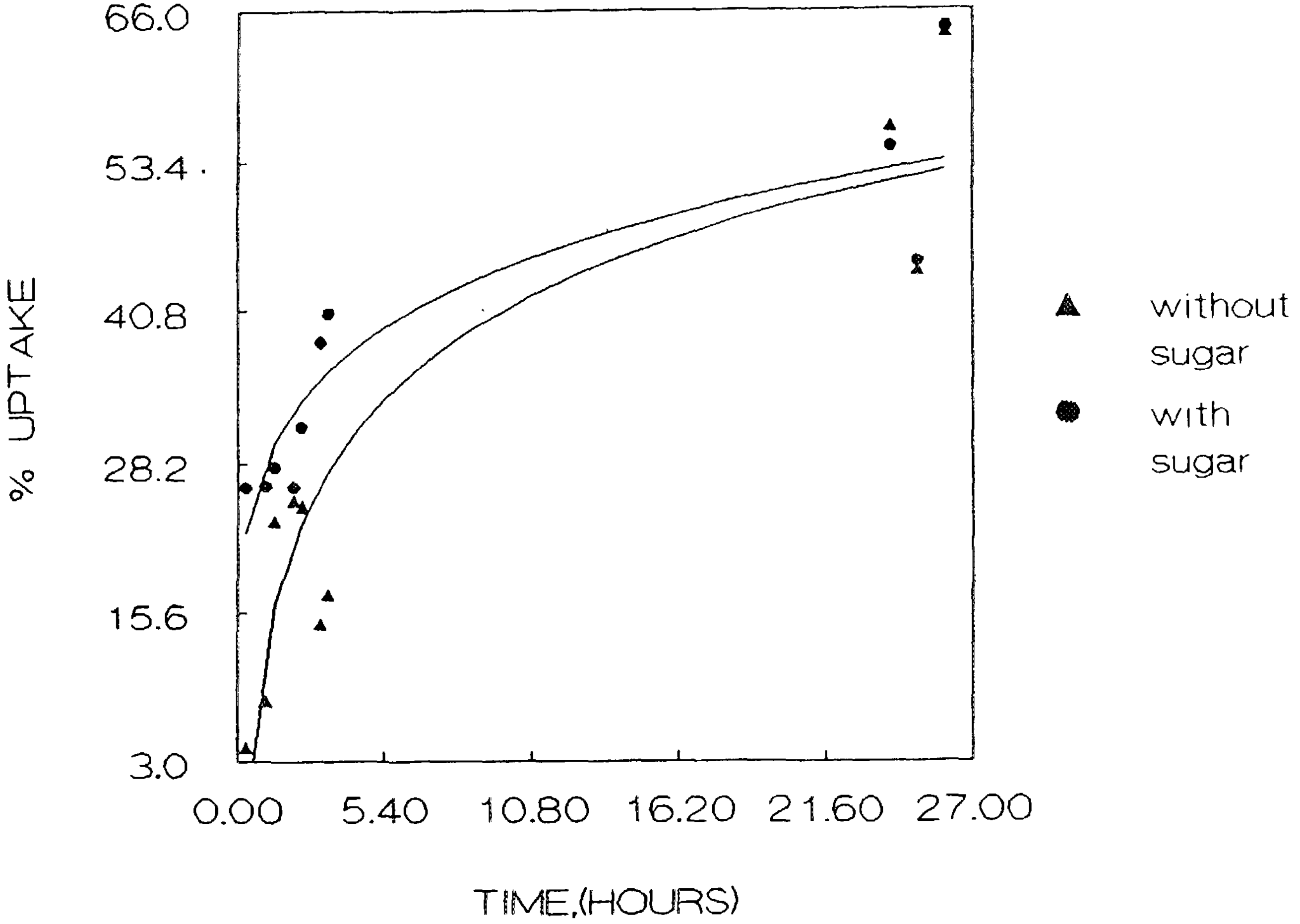
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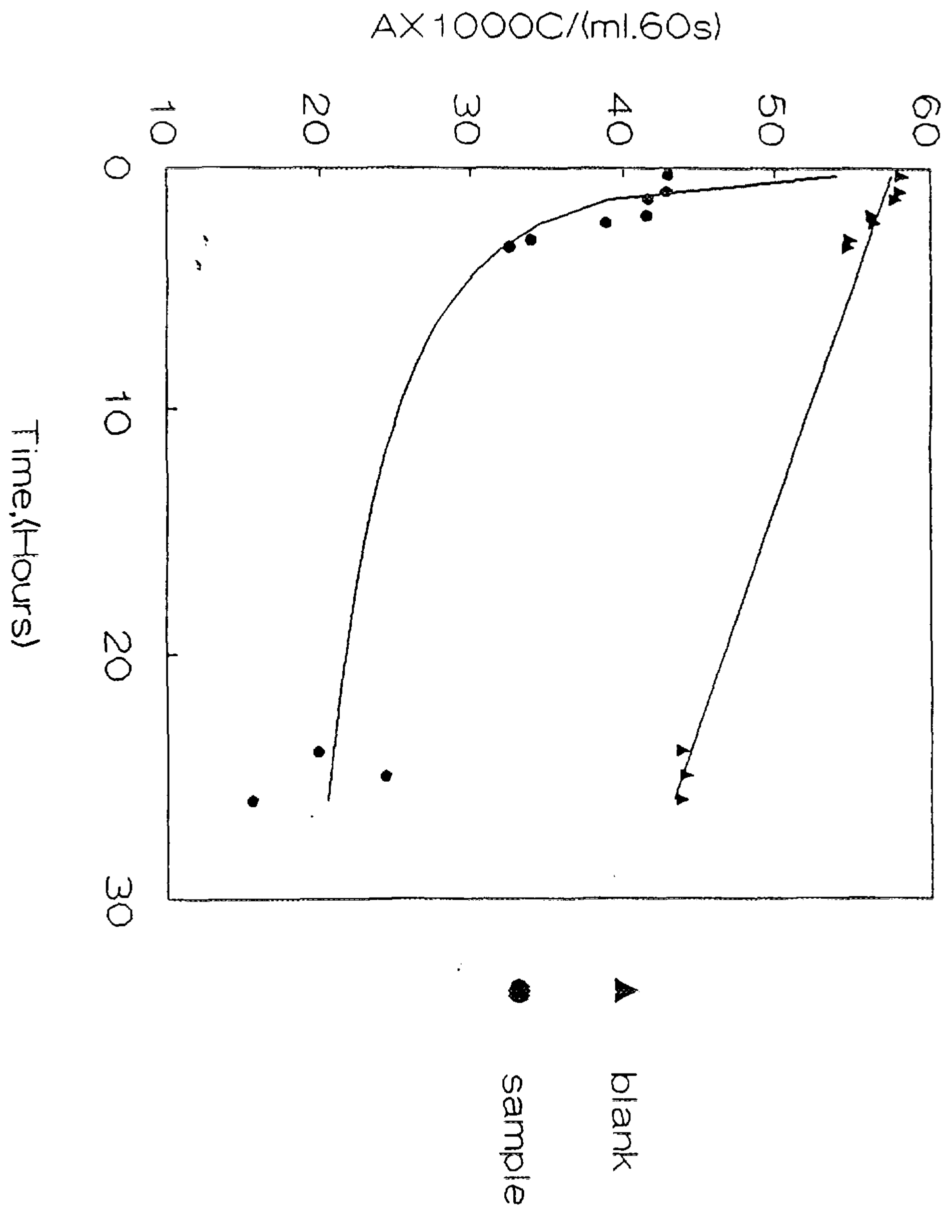
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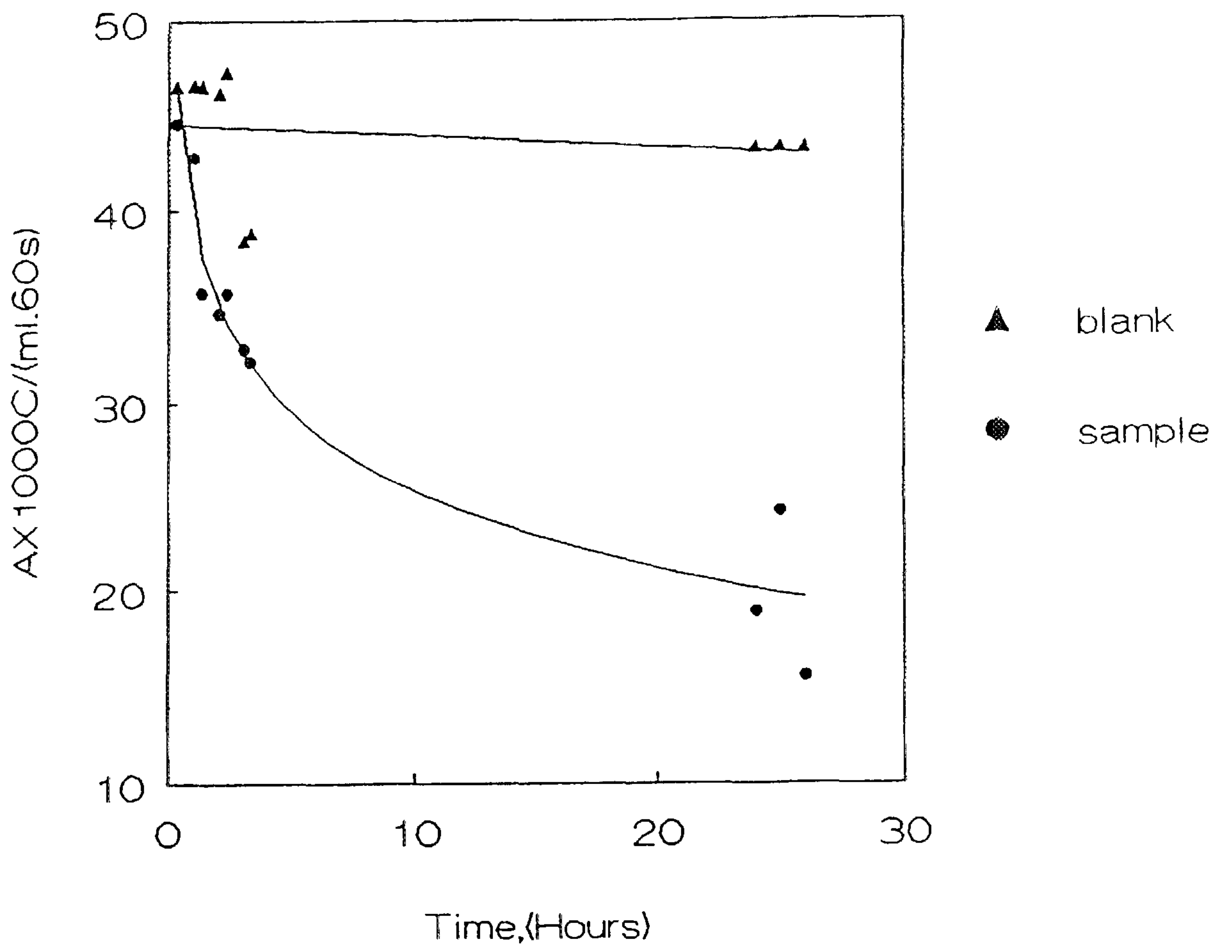
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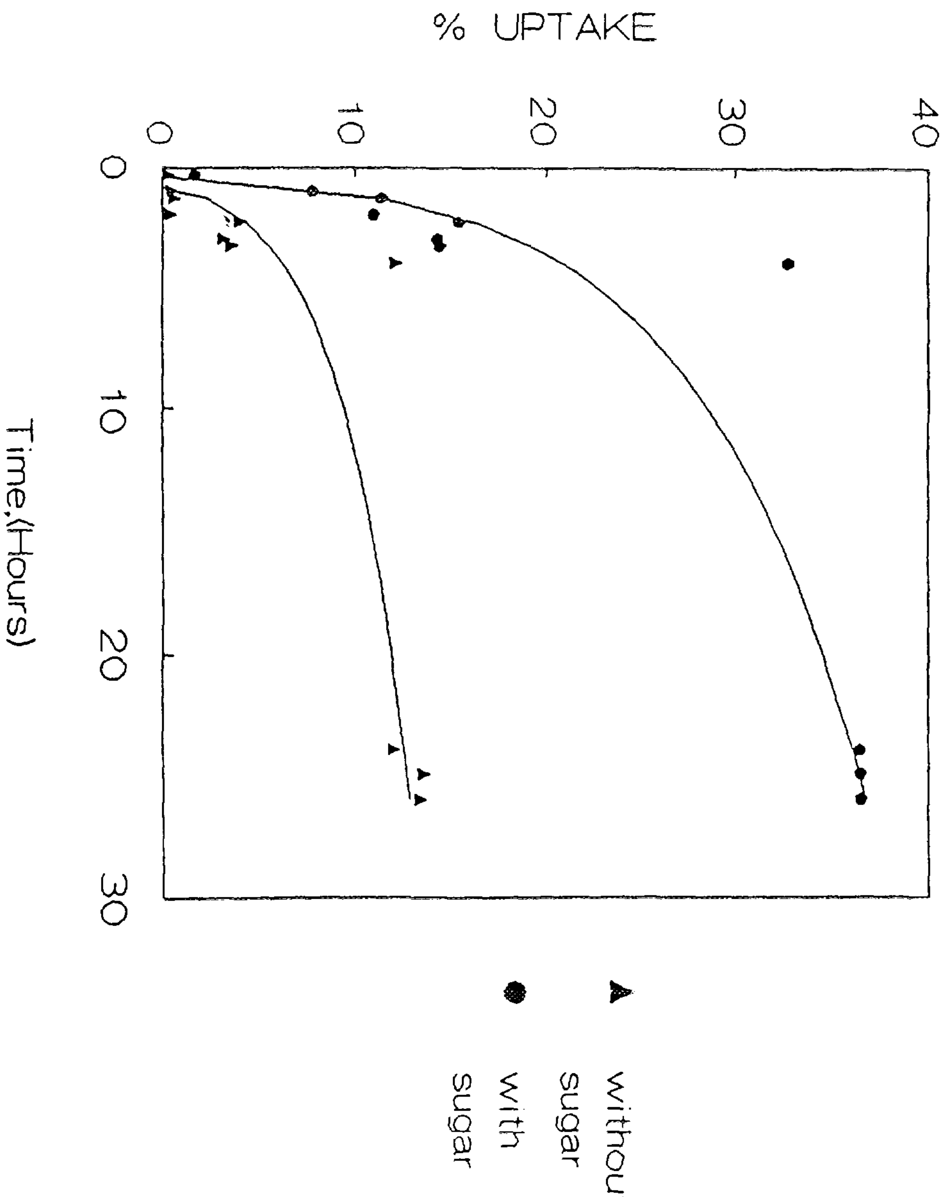
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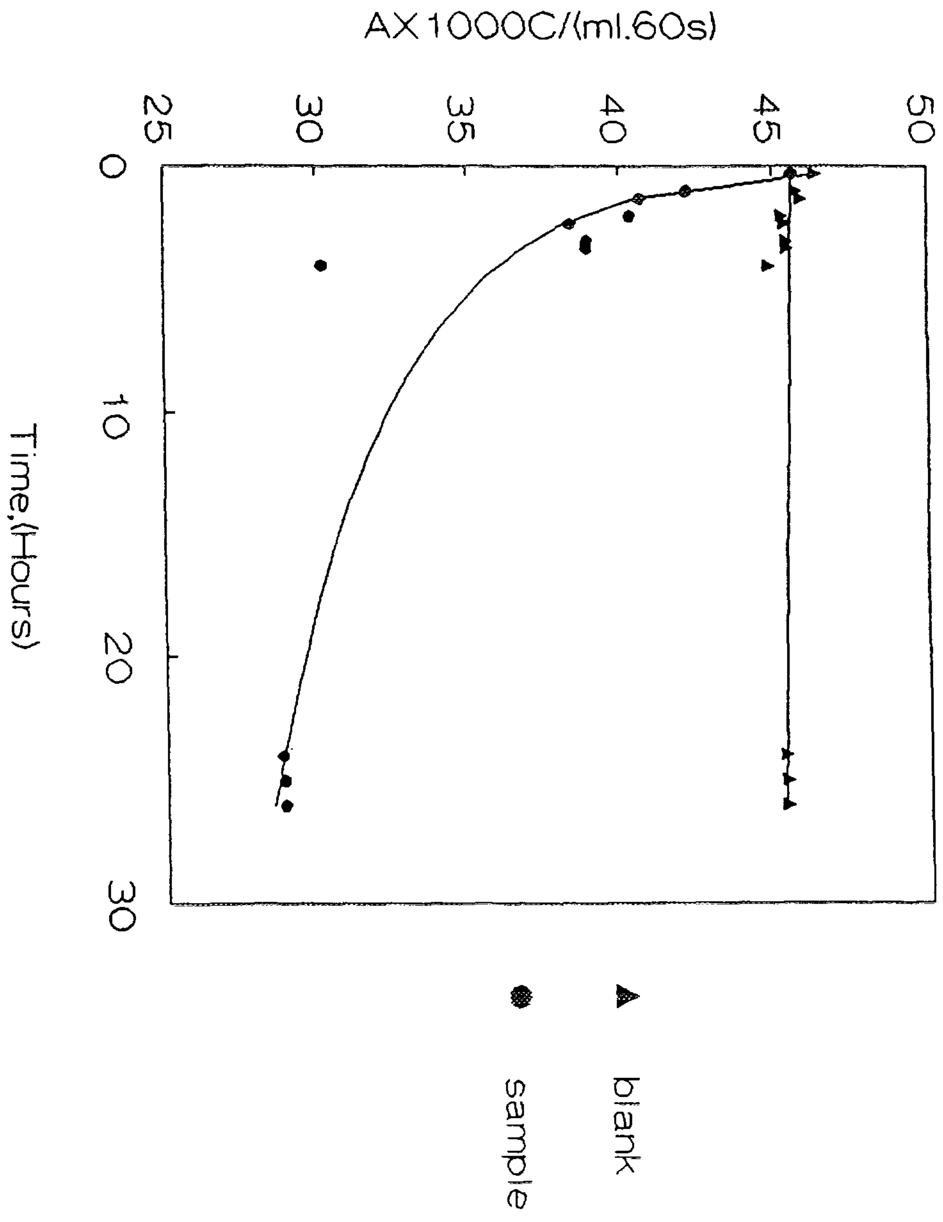
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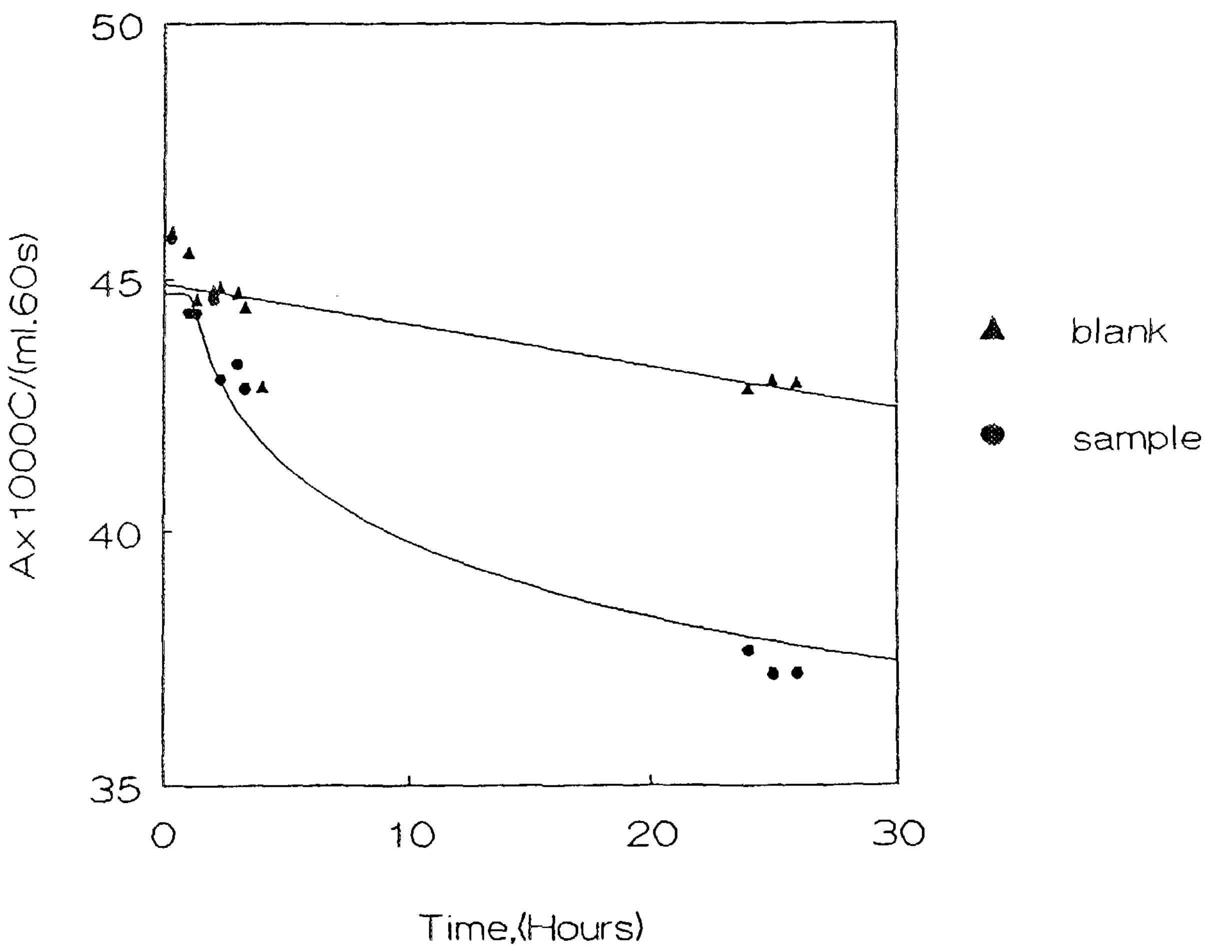
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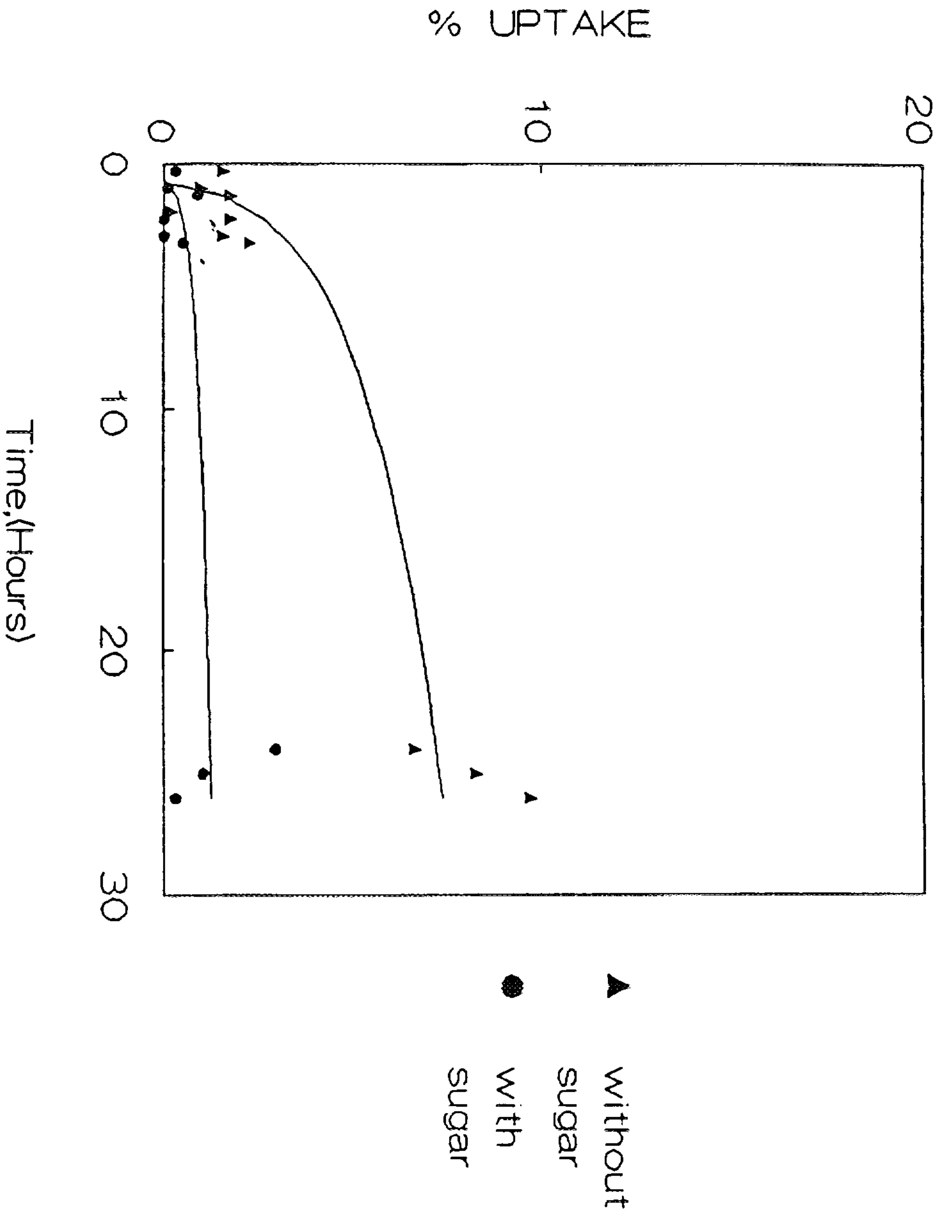
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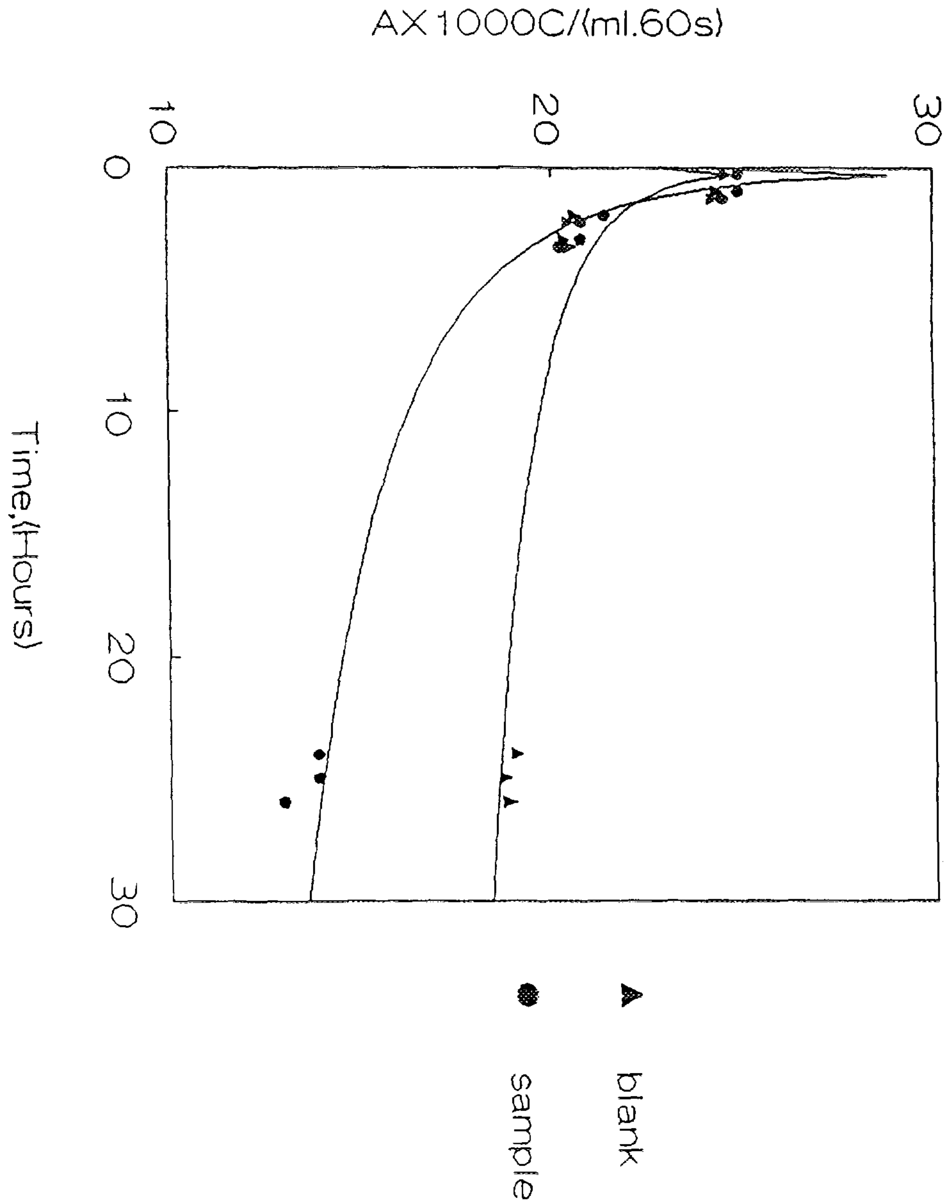
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