The Determination of Lead in Paint Films with a Portable Isotope Fluorescence Analyser

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Although there are numerous environmental sources of lead of significance for children (1) the major lead hazard in most urban populations is domestic paint (2). Conventional lead screening programs have previously been focussed on the child rather than his environment and so detect only those children who have accumulated a sufficient body burden of lead to render the tests positive. Although such programs have shown an annual poisoning rate of 0.5% among children at risk (3) they fail to identify those dwellings that are potential hazards for children not yet exposed. Chemical analysis of paint from surfaces accessible to children have shown that a wide range of lead contents may be present in homes of varying age and social status (4). Paint sampling in this way has disadvantages in that the subsequent analysis is relatively time consuming and costly and that the painted surface must be damaged so that a representative full-thickness sample may be obtained.

The portable isotope fluorescence analyser has long been used by geologists for the determination of the mineral content of ores but has not previously found application in this field. The apparatus is based on the principle of x-ray fluorescence and has the advantages that it is portable and that it can be applied repeatedly to any surface without damage. Preliminary studies have suggested that the device might find application in the determination of lead in domestic paint films in situ. In this paper the apparatus and its application to the analysis of paint films both in the laboratory and in the domestic environment are described.

Apparatus

The device employed was the Portable Isotope Fluorescence Analyser manufactured by Rank Precision Instruments Ltd., London, England. It comprises a portable battery-powered ratemeter which is connected by means of a flexible

for application to the test
weight of the assembly is 7.5
contains a radioactive source
mCi) sealed in an aluminium c
shielded when not in use by a
shutter which is displaced on
being applied to the test sur
simultaneously operated. The
the instrument when not in us
mrad/h and thus presents no h
The radiations emanating from
excite a fluorescent x-radiat
the test material, are uraniu
keV, which penetrate to an ef
on its composition, but solde
The fluorescent emission aris
enters the probe unit through
aperture surrounding the sour
through one of a pair of bala
ected and measured by means o
sodium iodide crystal and pho
housed in the probe. The bal
gallium or germanium and are
cut off emissions above and b
lead emission at 1.175 Å. Gi
the effective lead content of
determined from the differenc
rates obtained when the filte
utively.

Standardisation

The observed difference
given element will vary accor
which the element is dispers
reading can be obtained with
element of sufficient thickne
with lesser concentrations wi
ternal absorption of the exci
tions. Ideally a series of s
ical composition would have t
test situation so that a star
in count rates against lead c
While this is impossible for
it is simply achieved for a
additions of a lead compound
sample from which uniform fil
dried to give a standard seri

In this study a commerci
undercoat domestic paint cont
1% lead was used as the stand

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of the paint, increasing weights of lead oxide (Pb_3O_4) were added and thoroughly mixed such that a series of paint films of lead content in the range 1-31% were obtained. Subtraction of the reading due to the lead content of the base paint allowed the construction of a calibration curve for the range 0-30%, the maximum reading was obtained by substitution of lead foil for paint to give 100% lead (Fig. 1). The readings obtained allowed

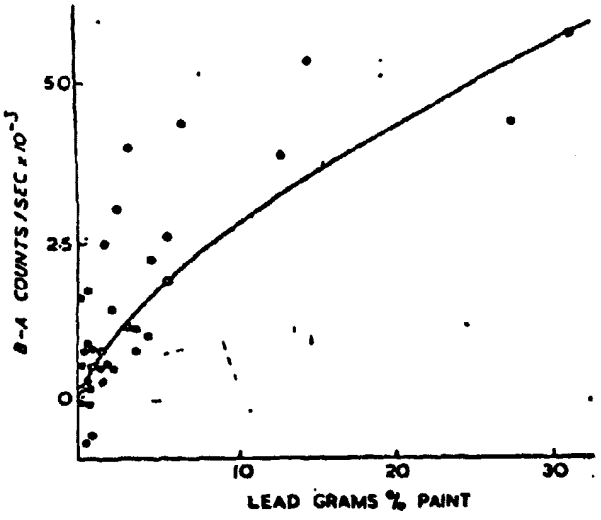

Figure 1. Count rate differences for paints of varying lead content a) laboratory prepared standards (open circles and curve) and b) domestic paint films in situ (closed circles).

determination of the lead content of a given film in the range 0-5% to an accuracy better than ± 0.2%. It was found that foils of 0.002" thickness gave readings that did not differ from those obtained from the surface of a lead brick, so that the effective thickness for the pure element was probably less than this. Standard paint films were obtained by pouring equal weights of the prepared paint standards (6.5 g.) into Petri dishes of uniform area (64 cm^2) supported on a top-loading bal The paint was allowed to cover the whole of surface such that a relatively thick film of depth was obtained. The standards were drie oughly and reweighed before use in order to the lead content per gram of dried paint fil

NON-HOMOGENEITY

Non-homogeneity of the test paint film introduce difficulties in interpretation of readings obtained and in some cases render i ible to obtain a representative figure. In situations this results from the successive ation of films of different lead or matrix c to a given surface. In its simplest form thi prises a double layered film but in many fie ations more complex films with multiple layer encountered. A double layered film may produ anomalous results in two ways depending on wh layer is superficial with regard to the analy probe. A surface layer of high lead content thus register a falsely high lead content for whole film, conversely if the lead containing is deep, the overlying film of low lead conte impair the efficiency of detection. The usua situation in the field involves the second of two situations in which the deepest layer of has the highest lead content.

In order to assess the effect of overlyi a series of standard paint films was prepared Petri dishes as described above to contain 1 After drying each film was covered with secon films of increasing thickness of the base pai low lead content (1.0% lead) such that each f weighed 8mg/cm^2 when dry. Successive observa showed a progressive decrease in the apparent concentration until this approached zero with covering paint film of 77mg/cm^2 equivalent to thinly brushed layers (Fig. 2).

FIELD TESTING

Thirty-four homes inhabited by families children in the 1-5 age group were selected group of families previously studied (4). T ection was arranged such that there was a wi scatter of lead concentrations in the domest to which the children had access. In each h reading was obtained from a painted surface room usually occupied by the children, in r this was a window sill or door frame. The

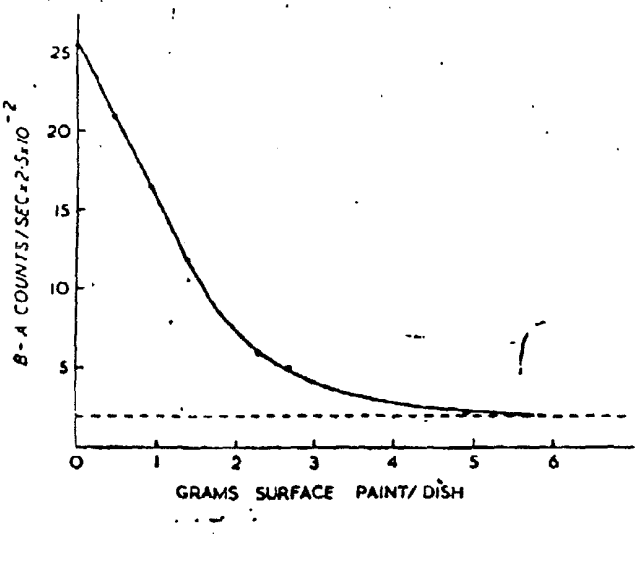

Figure 2. Graph showing the decrease in count rate difference for a paint containing 31 g% lead with successive applications of a second paint of low lead content (1.0 g%) in a dish of 64 cm^2. The interrupted line indicates the value obtained with the 1.0% lead containing paint alone.

fluorescence analyser was standardised in each home by means of a standard paint film previously prepared in the laboratory but in practice no appreciable change in machine performance occurred between home visits. Several readings were obtained from each surface to ensure that local variations in paint film thickness or lead content did not bias the results. After each series of readings a full thickness specimen of the paint film weighing about 50-100 mg. was obtained from the surface with the aid of a stainless steel scalpel blade. Chemical analysis of each paint specimen was made after wet digestion by means of a semiautomated alkaline dithizone method (6) and the results compared with the analyser readings.

FINDINGS

In general there was good correlatio
the chemical and x-ray methods and the in
results are given in Figure 1. which also
part of the standard curve derived in the
Curve fitting of the data from the domest
together with statistical analysis was un
by means of a least squares program with
1950E computer and the derived curve toge
95% confidence limits are reproduced (Fig
is evident that the scatter of results wa
an apparent zero lead content could be ob
the analyser in a paint film with an actu
tent of 5% and that conversely a count ra
as $2.5X10^3$ cps could be obtained with ver
concentrations. Similarly the wide separ
the 95% confidence limits require that a
of $3.0 X10^3$ cps before it could be inferr
that degree of certainty that the lead co
the paint film exceeded 1%, conversely su
rate could equally indicate a lead conten
8%.

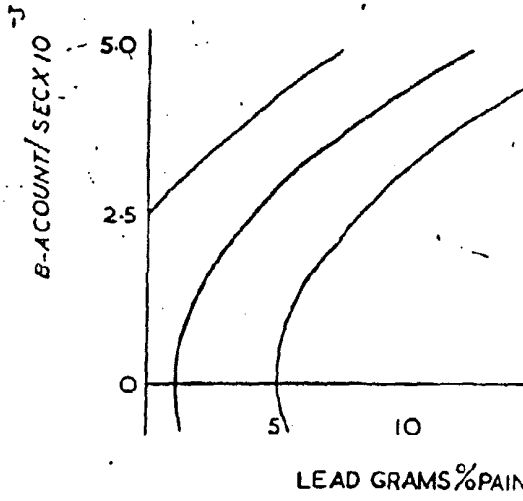

Figure 3. Best fit curve and 95% confiden
for domestic paint film data with lead c
the range 0-15%.

In its present form it is unlikely that this type of apparatus could find application in lead screening programs since it is incapable of discriminating between lead contents of domestic paint films in the 0-6% range. These findings are in marked contrast to the laboratory results for a series of standard paints and almost certainly result from the non-homogeneity and the variable thickness of paint films encountered in the field.

SUMMARY

The application of x-ray fluorescence to the determination of the lead content of paint films was evaluated using a portable isotope fluorescence analyser. Accurate determinations were achieved in the laboratory using prepared films in which the lead was dispersed through matrices of constant composition in a single layer. The presence of lead could be masked by overlying paint films of low lead content and was almost obscured by an overlying paint film of 77 mg/cm^2. The results for domestic paint films correlated with chemical analyses but the confidence limits were too widely separated to allow application of this technique to lead screening programs. The field results probably reflect non-homogeneity of domestic paint films.

Acknowledgements

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