EXTRACTION AND SEPARATION OF $^{60}$Co AND $^{65}$Zn HALIDES FROM H$_2$SO$_4$ WITH TBP AND AMBERLITE LA-2

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A systematic study is presented on the extraction of $^{60}$Co and $^{65}$Zn bromides and chlorides from H$_2$SO$_4$ with tri-n-butyl phosphate (TBP) and Amberlite LA-2. It has been found that the presence of a little HBr or HCl enhances the extraction of the two isotopes with both solvents. The extractions of $^{60}$Co and $^{65}$Zn have been studied as functions of the acidity (HBr, HCl or H$_2$SO$_4$) in the aqueous phase, and of the diluent and solvent concentrations in the organic phase. The presence of water-miscible alcohols or acetone enhances extraction. A suggested extraction mechanism is presented in the light of the obtained results.

Introduction

The separation and analysis of cobalt and zinc at the trace level is very important in biological and medical investigations, since they represent the active agents of many pharmaceuticals. On the other hand, the isotopes $^{60}$Co and $^{65}$Zn are two of the most important contaminant isotopes, as they have long half-lives and their gamma-radiations have high energy. The separation of the two isotopes from other elements and isotopes is therefore important in the processing and reprocessing of atomic fuel, as well as in the treatment of radioactive wastes. The simplicity of liquid-liquid extraction makes the technique easily adaptable to remote operation, which is necessary particularly when dealing with highly radioactive solutions. Few organic solvents are known to be stable to the effects of $\gamma$-radiation. Of these solvents tributyl phosphate (TBP) and long-chain aliphatic amines (for example, Amberlite LA-2) are the most stable and have in fact been widely used in the technology of radioactive solutions. It has been found that the extraction of cobalt and zinc with both solvents is either low or quite negligible from pure sulphuric acid solutions up to the highest acidity. Extraction of the two elements from hydrochloric and hydrobromic acids is not favourable since the former acid is highly corrosive and the latter is rather expensive and oxidizable. Fortunately, the presence of quite low concentrations of hydrochloric or hydrobromic acids appreciably increases the extraction of both elements from sulphuric acid solutions of intermediate normalities. This paper summarises systematic work on the extraction of $^{60}$Co and $^{65}$Zn with solutions of TBP and Amberlite LA-2 from the three pure acids and their binary
mixtures. Best conditions for extraction and separation of the two isotopes have
been determined, while the extraction mechanism is discussed in the light of the
obtained results.

Previous work on the extraction of cobalt and zinc with the above solvents dealt
with various other systems.¹⁻⁷

**Experimental**

**Apparatus**

An ECKO scintillation counter connected to a well-type NaI(Tl) crystal and a
phototube was used for activity measurement. A Telefunken γ-ray spectrometer
(type MS Str. 1104/1) connected to an MS Sz 831/2 NaI(Tl) detector was used to
check the purities of the applied radioisotopes (⁶⁰Co and ⁶⁵Zn).

**Isotope solutions**

The isotopes ⁶⁰Co and ⁶⁵Zn were prepared by dissolution of pile-irradiated
metals in concentrated hydrochloric or sulphuric acids. Irradiation was carried out
in the Egyptian Research Reactor (RRI) at Inshas for 48 hrs.

**Solvents**

The solvents used were TBP (B. D. H.) and Amberlite LA-2, N-lauryl trialkyl methyl
amine (Rohm and Haas), with a molecular weight between 353 and 395.⁸ Solutions
of the solvents with non-polar diluents (Reagent grade benzene, xylene, carbon
tetrachloride or Egyptian "Sunrise odourless kerosene") were prepared by volume.
Unless otherwise stated, benzene was used for dilution of both solvents.

**Procedure**

Extraction experiments were carried out in glass tubes. The appropriate acidity
was achieved by adding a calculated amount of concentrated acid to water (or water
with which another acid or additive had been mixed). Mixing with concentrated
sulphuric acid was done while cooling in an ice-bath. Solutions were then allowed
to attain room temperature (18 ± 4 °C). A trace amount of cobalt or zinc (10⁻⁴M),
labelled with its radioisotopes, and a volume of the organic phase equal to that of
the aqueous phase were then introduced, and mixing was carried out on a mechan-
ical shaker for 30 min. Preliminary experiments showed that this time is more
than enough for equilibrium to be reached and extraction is not influenced by tem-
perature fluctuations within the mentioned range. The distribution ratio (E) was
determined experimentally as the ratio of the activities of the tracer in the organic
and aqueous phases.