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Studies on Liesegang rings of cobalt hydroxide in 1% agar gel medium

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ABSTRACT

The present work deals with the studies on periodic precipitation of cobalt hydroxide system in 1% agar gel medium. For this purpose ammonium hydroxide was used as an outer electrolyte and cobalt chloride as an inner electrolyte. The effect of inner electrolyte concentration on the morphological characteristics of periodic precipitation was studied. These include size of the rings, spacing between the rings and number of rings produced per day. The concentration of reacting ions within the ring and in between successive rings was estimated by atomic absorption spectroscopy technique. The obtained results were verified on the basis of spacing law, time law and width law. The study also includes determination of diffusion coefficient of inner electrolyte at studied concentrations.

1. Introduction

Interdiffusion of two electrolytes and precipitation reaction between them lead to the formation of quasi-periodic pattern, this phenomenon is called Liesegang rings. A number of explanations on the mechanism of this phenomenon have been presented by various scientists; among them the ‘supersaturation theory’ formulated by Ostwald explains almost all the facts qualitatively and a large number of systems have been studied by different workers [1–3]. In our previous paper we have reported studies on Liesegang rings of sodium molybdate in agar gel medium [4]. The present paper deals with studies on the periodic precipitation pattern of cobalt hydroxide system in 1% agar gel medium at 25 °C. As the periodic precipitation is related to diffusion we have also studied the diffusion of inner electrolyte using the zone diffusion technique for the same concentration used in periodic precipitation formation. The obtained values are then compared with theoretical values.

2. Experimental

All chemicals used for the experiments were AR grade: bacteriological agar gel powder (HiMEDIA, Laboratories, Mumbai), ammonium hydroxides (MERCK India), and cobalt chloride (Qualigen). The cobalt chloride was used as an inner electrolyte and ammonium hydroxide as an outer electrolyte. The detailed procedure is explained in our previous paper [4]. After formation of the rings the gel was removed from the tube; rings were dissolved in slightly acidic water and diluted to 100 ml. The concentration of ions was estimated by using an atomic absorption spectrophotometer (LABINDIA — 7000). The Liesegang rings were studied for different concentrations and pH of inner electrolytes.

As the Liesegang phenomenon is governed by diffusion of ions, we have also studied the diffusion of inner electrolyte used for cobalt hydroxide ring. The electrolyte diffusion coefficient of $CoCl_2$ was measured at different concentrations using 1% agar gel. The diffusion coefficients were measured using zone diffusion technique the details of which are described in a previous paper [5].

3. Results and discussion

3.1. Periodic precipitation

When NH_4OH diffuses into inner electrolyte, $CoCl_2$, the following reaction takes place,

$$CoCl_2 + 2\,NH_4OH \rightarrow Co\,(OH)_2\downarrow + 2\,NH_4Cl$$

and the precipitate of cobalt hydroxide was formed. In order to get clear rings the pH of the system was varied. Rings obtained at various pH are shown in photographs 1–3.

At original pH (4.8) of inner electrolyte (Fig. 1) rings formed were not well separated, Hence, the pH of inner electrolyte was changed, the developed Liesegang rings of cobalt hydroxide system at various pH of inner electrolyte are shown in Fig. 2.

After studying system at various pH (Fig. 2) we have selected pH 2.5 for further studies.

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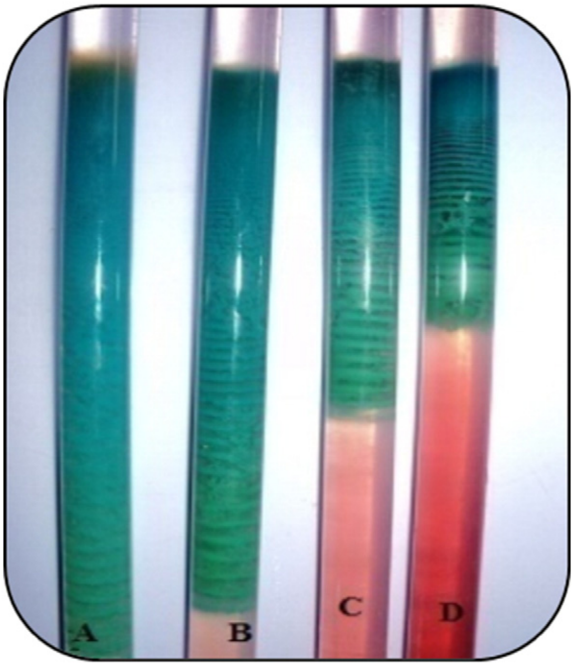

Fig. 1. Liesegang rings of cobalt hydroxide system at pH 4.8 formed by cobalt chloride (concentration for tube A: 0.025 M, B: 0.05, C: 0.1 and D: 0.2 M) and ammonium hydroxide (conc. for tubes A, B, C, D 2 M).

It was observed that Liesegang rings were closely packed near the interface and the distance between the rings gradually increased with increasing distance of ring from gel interface (Fig. 3). The various morphological characteristics of rings were studied and the different empirical laws were verified.

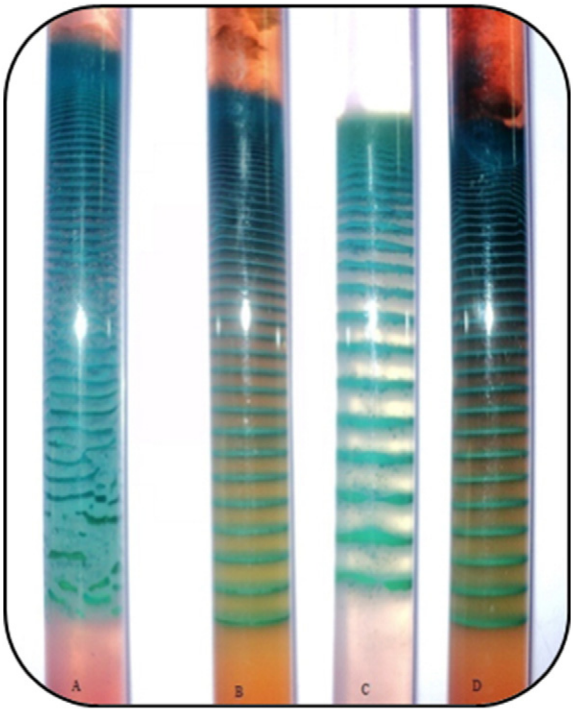

Fig. 2. Liesegang rings of cobalt hydroxide in 1% agar gel formed by cobalt chloride 0.05 M and ammonium hydroxide 2 M (A: pH 2, B: pH 2.5, C: pH 3.5 and D: pH 4.5).

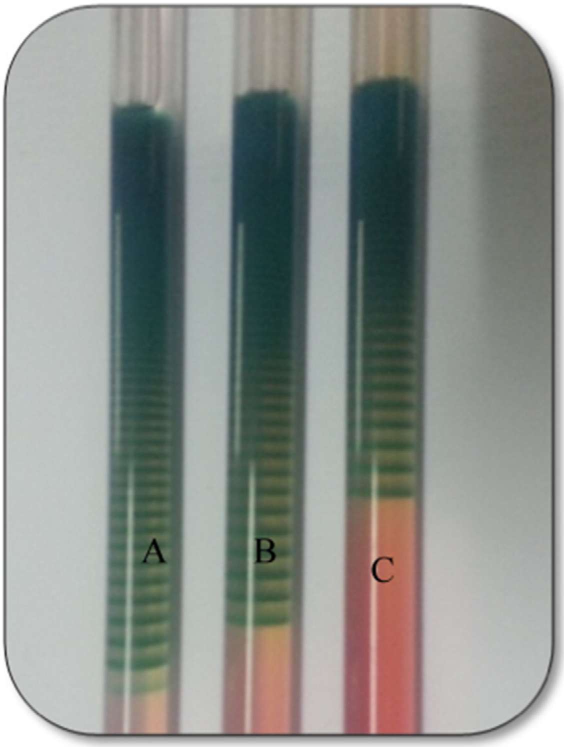

Fig. 3. Liesegang rings of cobalt hydroxide at pH 2.5 (A, B, C NH_4OH conc. 2 M, and A, B, C 0.05 M, 0.1 M, 0.2 M $CoCl_2$ respectively).

3.2. Verification of different laws of Liesegang rings

The Liesegang ring formation on the macroscopic scale is visible to the naked eye and the striking feature is that these patterns obey simple generic laws viz. time law, spacing law and width law.

The time elapsed before the formation of the nth ring 't_n' and the distance of the ring from gel interface 'x_n' follows the general law known as the 'time law' [6].

$$x_n \quad \alpha \quad \sqrt{t_n} \tag{1}$$

The plot of x_n^2 vs t is shown in Fig. 4.

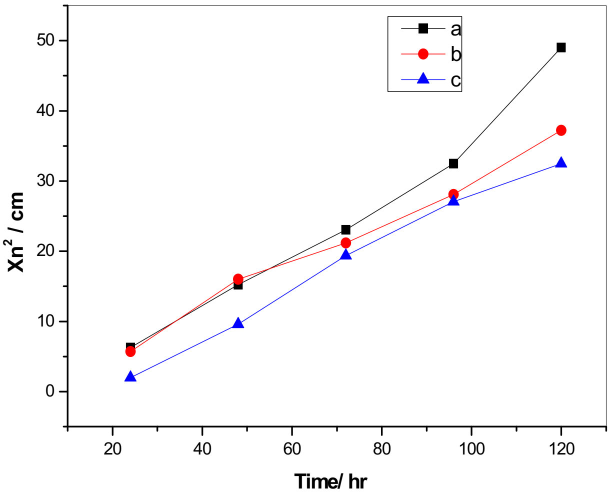

Fig. 4. Verification of time law (a, b, c: 2 M NH_4OH, a: 0.2 M $CoCl_2$, b:0.1 M $CoCl_2$ and c: 0.05 M $CoCl_2$).