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The Induction of Filamentous Growth in *Escherichia Coli* by a Palladium(II) Complex of *L*-Serine

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Several platinum complexes can induce filamentous growth in *Escherichia coli* [1–3]. The long forms of *E. coli* can also be induced by rhodium(III) salts [4], rhodium(III) complexes with organic ligands [3] and ruthenium(III) complexes [5]. Although Kirschner and collaborators [6] noted that *cis*-dichloropiperidine palladium(II) can induce filamental growth in *E. coli*, other workers [3, 5] reported that palladium(II) complexes produced little or no filamentation in this bacterial system. We showed that, whereas mixtures of *L*-glutamine with tetrachloroplatinate(II) ions induced filamentous growth in *E. coli*, filamentation was not observed for mixtures of *L*-glutamine with tetrachloropalladate(II) ions [7]. Similar results were recorded [7] for mixtures of tetrachloroplatinate(II) ions and tetrachloropalladate(II) ions with *L*-aspargine. We reported, however, that mixtures of *L*-serine with tetrachloropalladate(II) ions can induce small filaments in *E. coli* [8]. The purpose of this communication is to report the preparation of two palladium(II) complexes of *L*-serine. One of these, caesium *cis*-dichloro-*L*-serinatopalladium(II), has been shown to induce filamentous growth in *E. coli*.

Farooq and collaborators [9] carried out potentiometric and pH-metric measurements on the *DL*-serine tetrachloropalladate(II) system. Although the potentiometric studies revealed that a species in which the amino acid and palladium were combined in a molar ratio of 2:1 was present in solution, the corresponding complex was not obtained in pure form [9]. Analytically pure samples of bis[*DL*-serinato] palladium(II) were prepared by Von Kollmann and co-workers [10] and Inomata and collaborators [11]. The latter authors noted that the infrared spectrum of their palladium(II) chelate was similar to the infrared spectra of other amino acid metal chelates which have *trans* configurations [11]. We found that bis[*DL*-serinato]palladium(II) is readily obtained by the methods of Von Kollmann, Inomata and collaborators [10, 11]. However, in order to prepare the corresponding chelate from *L*-serine, Von Kollmann's procedure had to be modified; it was necessary to de-ionize the reaction mixture with Amberlite MB3 mixed-bed resin. Bis[*L*-serinato]palladium(II) crystallized from the de-ionized solution. It is also possible to prepare the bis chelate from *L*-serine using Inomata's method followed by removal of ions with Amberlinte MB3 resin. An X-ray crystal structure, performed by Dr. R. S. Vagg [12] in this laboratory, revealed that bis[*L*-serinato]palladium(II) has the *cis* configuration.

Ley and Ficken [13] reported the preparation of potassium *cis*-dichloro-*L*-alaninatoplatinum(II). Using a similar procedure we obtained a sample of crude potassium *cis*-dichloro-*L*-serinatopalladium(II). Cleare's method [14] was used to convert the potassium salt into caesium *cis*-dichloro-*L*-serinatopalladium(II) which was purified by recrystallization from water.

Caesium *cis*-dichloro-*L*-serinatopalladium(II) was tested in the *E. coli* system. The filamentous growth observed at a concentration of 8 $\mu g/cm^3$ is shown in Fig. 1, and the control *E. coli* without the palladium complex is shown in Fig. 2. Durig and collabor-

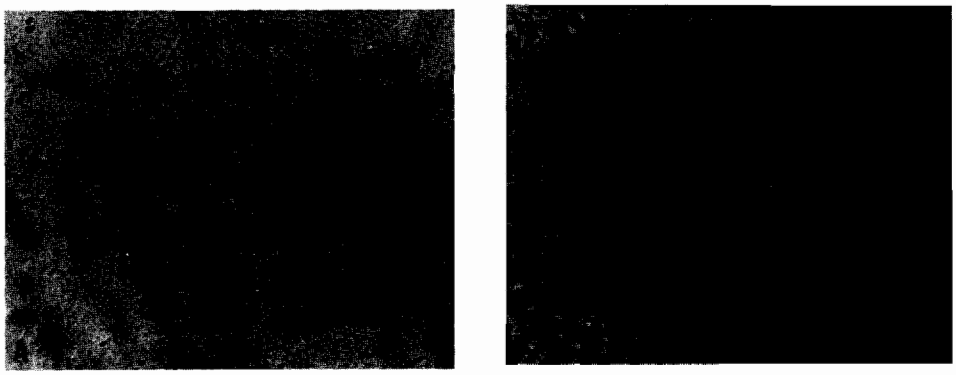

Fig. 1. *Escherichia coli* incubated with caesium *cis*-dichloro-*L*-serinatopalladium(II) at a concentration of 8 $\mu g/cm^3$. The photomicrographs were taken from a slide stained with crystal violet using A) 400× magnification and B) 1000× magnification.

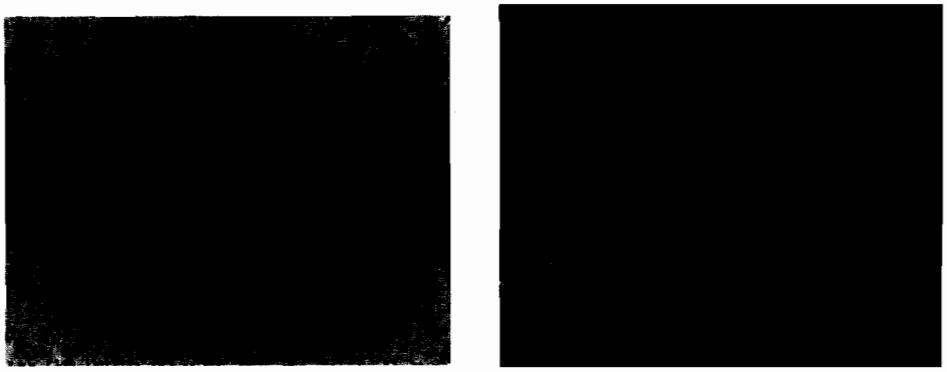

Fig. 2. Control sample of *Escherichia coli.* The photomicrographs were taken from a slide stained with crystal violet using A) 400X magnification and B) 1000X magnification.

ators [5] observed filamentous growth of *E. coli* with *cis*-triaminetrichlororuthenium(III) at a similar concentration (6 $\mu g/cm^3$). At a concentration of 14 $\mu g/cm^3$ caesium *cis*-dichloro-*L*-serinatopalladium-(II) produced some long filaments, but there was also considerable cell death.

Experimental

Cis-bis[L-serinato]palladium(II)

A solution of potassium tetrachloropalladate(II) (0.81 g) and *L*-serine (1.1 g) in water (10 cm^3) was adjusted to pH 8 with 1 *M* sodium hydroxide and concentrated to half its volume. After standing at 5 °C for several days, the mixture was diluted with water and de-ionized by passing the solution down a column of Amberline MB3 resin. The eluate was concentrated to about 20 cm^3 at 40 °C and 20 mm, and the yellow chelate (0.15 g) crystallized slowly from the filtered solution. *Anal.* Found: C, 22.94; H, 3.85; N, 8.67; Pd, 36.8. Calcd. for $C_6H_{12}N_2O_6Pd$: C, 22.91, H, 3.85; N, 8.91; Pd, 33.8%.

Caesium cis-*dichloro*-L-*serinatopalladium(II)*

A mixture of *L*-serine (2.1 g) and potassium tetrachloropalladate(II) (3.2 g) in water (60 cm^3) was heated 3 h on a boiling water bath. Absolute ethanol (450 cm^3) was added to the filtered reaction mixture, and the light orange precipitate (1.7 g) was filtered off. The product was reprecipitated from water (10 cm^3) with ethanol (40 cm^3). A brick-red caesium salt (1.2 g) precipitated on adding excess caesium chloride to a solution of the potassium salt (1.45 g) in water (10 cm^3). The caesium complex was purified by two recrystallizations from water (yield 0.2 g). *Anal.* Found: C, 8.83; H, 1.55; Cl, 17.2; N, 3.43. Calcd. for $C_3H_6Cl_2NO_3Pd$ Cs: C, 8.70; H, 1.46; Cl, 17.1; N, 3.38%.

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