the ascending part of the aorta. Blood flow in the common carotid artery and femoral artery was determined in the same way. A standard lead I electrocardiogram was used in the tests.

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ACTIVITY OF COLLOIDAL SILVER PREPARATIONS TOWARDS SMALLPOX VIRUS

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The bactericidal properties of silver have been widely known for a long time. However we have found no work devoted to the investigation of its antiviral properties (except on influenza virus). The present study is the first of a series of investigations on the antiviral activity of preparations containing colloidal silver. The LIVP strain of smallpox vaccine (SPV) was chosen as the model.

EXPERIMENTAL

Tris-phosphate buffers of pH 7.2 and 8.9 were used as the background solution for preparing test solutions of SPV. The final concentration of viral particles in the test solution was brought to $1 \cdot 10^5$ BAU/ml (lg).* The test solution was used at 18°C. Assessment of the antiviral properties of the colloidal silver solutions was carried out in vitro.

Aqueous solutions (0.05%) of collargol and protargol, medicinal preparations of colloidal silver, were used in the experiments. A suspension of SPV was added to these solutions to a final concentration of 10^5 BAU/ml (lg). Test samples were withdrawn after 60 min exposure for the assessment of results.

Quantitative assessment of the SPV in the samples was carried out immediately after the end of the exposure on the chorio-allantoic membrane of 11-13 day old chick embryos by the usual method. The virucidal action of colloidal silver solutions was investigated using the serial dilution method.

RESULTS AND DISCUSSION

Results of the investigation of the biological activity of collargol and protargol towards smallpox virus are given in Table 1. The results of investigating the dimensions of the silver particles are given in the same Table [1].

The initial concentration of viral particles was $6.8 \cdot 10^5$ BAU/ml (lg) and the final $6 \cdot 10$ BAU/ml (lg) for collargol and $1 \cdot 10^3$ BAU/ml (lg) for protargol. The reduction of the concentration of viral particles was therefore about 11,000 and 700 times for collargol and protargol respectively (see Table 1). If the reduction in viral particle concentration in

*BAU denotes biological activity units.

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TABLE 1. Biological Activity of Collargol and Protargol Towards Smallpox Virus

Ag content, wt. %	Sample	Mean surface dimension of silver particles, nm	Biological activity towards smallpox virus					
			initial concentration, BAU/ml (lg)	final concentration, BAU/ml (lg)	reduction of viral concentration, times	relative reduction of viral concentration		
						per g preparation	per g silver	per m^2 silver
74,2	Collargol	9,9	$6{,}8 \cdot 10^5$	$6 \cdot 10^1$	11 333	$16{,}7a$	$1{,}6a_1$	$8{,}3a_2$
7,1	Protargol	1,9	$6{,}8 \cdot 10^5$	$1 \cdot 10^3$	680	a	a_1	a_2

protargol is assigned the value a, then the reduction in concentration for collargol calculated per g of preparation is 16.7 a_1, i.e., the activities of the preparations calculated per g preparation differ by more than one order of magnitude.

The silver content of collargol (74 wt. %) exceeds that of collargol (7 wt. %) by an order of magnitude. Calculating per g silver and assigning the value a_1 to the reduction of viral particle concentration in protargol, the relative reduction for collargol is 1.6 a_1, i.e., the activities of the preparations calculated per g silver are close to one another.

We have reported [1] the silver particle size distribution in collargol and protargol calculated from electron microscopic data and low-angle x-ray dispersion (LAXD). By analyzing the data on the silver particle size obtained by these methods and by comparing these with data of x-ray diffraction, Auger electron spectra and diffuse reflection electronic spectra, it was concluded that the distribution was calculated most reliably by the LAXD method.

We have used such data in the present study. The mean silver particle surface diameters calculated from them were 9.9 and 1.9 nm for collargol and protargol respectively.

If the action of the silver particles on the virus is effected through Ag^+ ions then the size of the specific surface of the silver particles in the preparations will be extremely important since the concentration of Ag^+ in solution is directly proportional to the size of the specific surface. The size of the specific surface is inversely proportional to the mean diameter of the particle surface [2]. The mean diameters of the silver particle surface for protargol and collargol, and therefore of their specific surfaces, differ 5.2 fold (see Table 1). If the reduction of viral concentration for protargol referred to 1 m^2 silver is taken as a_2 the relative reduction of concentration for collargol is therefore 8.3 a_2.

According to [1] a large proportion of the silver particles in protargol are about 1 nm in size. These are readily oxidized by the oxygen of the air, particularly in aqueous solution. Consequently if the antiviral action of the preparations is effected through Ag^+ silver ions then the activity of protargol calculated per unit silver surface should be either the same as or even greater than that of collargol. We observed the opposite picture. Consequently it is suggested that silver is active towards smallpox virus in the metallic state.

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