

the three species examined. For this reason, the magnetite unit is always separated spatially from the apatite unit by the lepidocrocite unit. The apatite unit in all three species is the largest (63 to 65 percent), the magnetite unit comprises about 33 percent, and the lepidocrocite unit consists of, at most, 2 percent of the mineral fraction of the denticles. However, the magnetite is the most extensively developed mineral on the denticle surfaces (Fig. 1), occupying about 60 percent, while the apatite mineral covers, at most, 38 percent of the surface area. The minerals recovered from the denticles of all mature teeth on the radula of adult individuals of *A. echinatum* consist, on the average, of 12 mg of the apatite mineral, 6 mg of magnetite, and 0.7 mg of lepidocrocite.

The minerals found in the denticles of the Chitonidae species have biologic and geologic implications. Magnetite was found in the denticles of two Chitonidae species (*I*), whereas the apatite mineral and lepidocrocite are new to chiton precipitates. The identification of lepidocrocite is of particular interest, because this is the first time that this mineral has been observed as a biologic precipitation product.

The Chitonidae in our study have shell plates composed of aragonite. The spicules in the two *Acanthopleura* species, as well as the girdle scales in the *Chiton* species, consist also of aragonite. When the denticle precipitates, namely magnetite, lepidocrocite, and the apatite mineral, are added, the chitons emerge as a rather unique group of organisms, in which as many as four different minerals can be precipitated by the tissues of a single individual.

Chitonidae are common intertidally on rocky shores of the tropical and subtropical seas; for instance, at Barbados, Chitonidae average 30 individuals and as many as 60 individuals per square meter. The mineral fraction of the mature denticles of the standing crop of Chitonidae per square meter is estimated to consist, on the average, of 300 mg of the apatite mineral, 150 mg of magnetite, and 10 mg of lepidocrocite—and of twice those amounts in the more densely populated areas.

The significance of chitons as possible contributors of magnetite to marine sediments has been noted (*I*). The apatite fraction of shallow-water marine sediments has been attributed to skeletal remains of fish and crusta-

ceans. However, our data indicate that, in the tropics and subtropics, the apatitic fraction of the shoal-water sediments should be, in part at least, derived from Chitonidae denticles. Sedimentary occurrences of lepidocrocite were formerly attributed to inorganic sources. My work indicates that this mineral also is a product of biosynthesis. The amounts contributed by the Chitonidae to the sediments are likely to be small. Nevertheless, it is necessary to distinguish in sedimentary lepidocrocites between the biologic and inorganically derived fractions.

H. A. LOWENSTAM

*Division of Geological Sciences,
California Institute of Technology,
Pasadena 91109*

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7. S. D. Lowenstam collected the chitons from Viña del Mar, Chile, and J. Westphal aided in the collection of the chiton samples from Palau, Caroline Islands.
8. P. E. Desautels of the U.S. National Museum supplied the reference sample of lepidocrocite (cat. No. R9593) from Horhausen, Germany. The dahllite standard, supplied by D. McConnell, consists of dental enamel from a post-Wisconsin mastodon tooth (Bluffton, Ohio) which has been chemically analyzed [D. McConnell, *Amer. Mineralogist* **45**, 209 (1960)].
9. The 2.004-Å line shown in the x-ray diffraction pattern of the reference sample (Fig. 3B) is not a recorded magnetite line.
10. The Ca and P contents were determined with the use of the chemically analyzed dahllite as a standard; the F content was determined with a fluorite standard.
11. Contribution No. 1445 from the Division of Geological Sciences, California Institute of Technology. Supported by grants GP-321 and G-20187 from the National Science Foundation. I thank M. Dekkers and A. Chodos for technical assistance.

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Polonium-210: Removal from Smoke by Resin Filters

Abstract. *Use of a mixed ion-exchange resin as a filter for cigarettes markedly reduces both the total amount of polonium-210 in mainstream smoke and the picocuries per milligram of smoke. This procedure effectively minimizes exposure of the lungs of smokers to alpha irradiation.*

Since the publication of Radford and Hunt's report on the presence of ^{210}Po in the mainstream smoke of cigarettes, many have investigated the presence of alpha-particle activity in tobacco (*1*). Although alpha activity in tobacco smoke is relatively low, much interest has been aroused in possible carcinogenic effects on the lung of the resultant irradiation, because of either the cumulative alpha dose or possible synergistic carcinogenic action with nicotine and tars.

We have extensively investigated the concentration of ^{210}Po in various domestic and foreign tobaccos. Our principal goal was reduction of alpha activity in mainstream smoke, with consequent reduction of the exposure of smokers' lungs to the activity, by seeking species of tobacco plants having naturally low contents of polonium. Also we attempted to determine the form in which ^{210}Po appears in the smoke, so that it could be controlled otherwise. In one experiment we used a mixed-bed ion-exchange resin in an attempt to remove ionized polonium from the smoke; all polonium apparently was removed. Other experiments

indicated that commercial cigarette filters (cellulose, charcoal-impregnated material, granular charcoal, or combinations of these) removes 50 percent or less of the polonium. The following procedure was designed to investigate more fully the unexpected efficiency of the resin filter.

We used a domestic brand of filter cigarettes, the filter consisting of a chamber containing granular charcoal, with rolled-cellulose elements above and below the chamber. All samples were smoked by machine (*2*). We used a set of parameters that we have adopted as our standard; they consist of eight puffs, each of 35 cm³ and 2-second duration, taken 58 seconds apart. The mainstream smoke was trapped by a 0.45-μ membrane filter and a flask containing 0.5N HCl. Earlier experiments in our laboratory had indicated quantitative removal of ^{210}Po by the membrane filter alone.

Our procedure was to smoke cigarettes first with the normal filter intact and then with the filter removed. Finally, cigarettes were smoked in which the granular charcoal of the normal filter had been replaced with

Table 1. Polonium content of mainstream smoke (from cigarettes of one brand) after various types of filtering. "Material" is material trapped by the membrane filter. Abbreviations: Rep exp, replicate experiments; cha, charcoal; cel, cellulose; res, resin.

Filter, type	Cigarette per sample (No.)	Rep exp (No.)	Material (mg)	Mainstream content per cigarette (pc)		Po:smoke (pc:mg)
				Average	S.E.	
None	20	2	0.0174	0.0156	0.0000	0.896
Cha + cel	20	2	.0052	.0078	.0000	1.500
Res + cel	20	2	.0086	.0012	.0004	0.140
Res + cel	10	5				
Res + cel	8	5				
	8	5	Content in resin	0.0136	0.0007	

ion-exchange resin; the resin from some of these cigarettes was analyzed for ^{210}Po content to confirm our opinion that the polonium removed was on the resin. In all instances the material deposited from the mainstream smoke on the membrane filters was analyzed for ^{210}Po by a reported method (3). Of the 11 packs of cigarettes used by us, ten came from the same carton so that possible variation in polonium content among cartons of the same brand would be minimized—a step justified by the lower polonium content in the mainstream smoke of this batch of cigarettes. Our other analyses of this brand of cigarettes, without filters, had shown higher contents (0.0263 pc per cigarette, in the mainstream) similar to those found by other authors. The resin used was a 20- to 50-mesh mixture (1:1) of cation- and anion-exchange resin (4) intended for water-demineralizer cartridges. The resin was removed from the cartridges and used as is.

All results (Table 1) have been corrected for reagent blank values, background, and recovery. They indicate that the normal filter on this brand of cigarettes removes 50 percent of the polonium in mainstream smoke, and that resin substituted for the charcoal removes 92 percent or more.

The polonium content of mainstream smoke was so low that indirect methods were used to confirm these results. From one pack of cigarettes, five with the filter intact were smoked through each of two tared membrane filters. The same was done with five cigarettes in which the charcoal was replaced with resin. The weight of residue collected on the membrane filter indicated that it collected on average 3.4 mg more material from the mainstream of each of the resin cigarettes than of each of the intact cigarettes. In part this finding reflected the fact that more of the resin cigarettes was smoked (the length of their butts averaged

40.5 mm against 44.2 mm for the intact cigarettes), but it may be that charcoal removes more organic material from mainstream smoke than does the resin.

To determine whether the lowered content of polonium in the mainstream smoke was due to removal by the resin, the resin from the five replicates listed in the last row of Table 1 was analyzed. The sum of this average value and the average of picocuries per cigarette, in mainstream smoke from the resin-filtered cigarettes, should equal the average number of picocuries per cigarette in mainstream smoke from unfiltered cigarettes. Failure of a *t*-test of this hypothesis to reject at the 95-percent level implied that we had accounted for all the polonium in mainstream smoke. A similar test of the hypothesis that the second and third values in column 5 of Table 1 are

equal was rejected at the 99-percent level.

We conclude that exposure of smokers' lungs to alpha activity is markedly reduced by incorporation of an ion-exchange resin in cigarette filters. This conclusion is based on the reasonable assumption that mainstream polonium occurs in a similar form in all domestic cigarettes. A crude cost analysis indicates that incorporation of resin would be a relatively inexpensive control measure: the 0.12 g of resin used per cigarette would cost about 0.5 cent per pack. This type of radiation control could be applied while further radiobiologic experiments are being designed to test the significance of the ^{210}Po content of mainstream smoke.

ERICH W. BRETTHAUER

STUART C. BLACK

Southwestern Radiological Health Laboratory, U.S. Public Health Service, P.O. Box 684, Las Vegas, Nevada

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Failure of Cycloheximide To Induce Tyrosine Transaminase in the Anesthetized Rat

Abstract. *It was recently reported that cycloheximide, an inhibitor of protein synthesis, induces tyrosine transaminase in the liver of adrenalectomized rats. We have been unable to confirm this effect in the anesthetized animal and our data show that cycloheximide inhibits the induction caused by hydrocortisone in adrenalectomized rats or by stress in intact rats.*

The activity of tyrosine transaminase (L-tyrosine: 2-oxoglutarate aminotransferase, EC No. 2.6.1.5) is markedly stimulated in rat liver by hydrocortisone (1), this stimulation being due to *de novo* synthesis of protein (2). It was recently reported by Fiala and Fiala (3) that cycloheximide, an inhibitor of protein synthesis (4), induces tyrosine transaminase to a value 250 to 300 percent above basal level in 4 hours. The effect was observed in the livers of both intact and adrenalectomized rats, and the increase was blocked in the adrenalectomized ani-

mal by puromycin. Moreover, Fiala and Fiala's data indicate that the antibiotic enhances the induction of tyrosine transaminase by hydrocortisone.

We were particularly interested in this report in view of recent developments concerned with regulatory processes affecting the rate of synthesis of tyrosine transaminase in rat liver. Kenney (5) has presented evidence supporting the view that this enzyme is normally repressed at the translation step of its biosynthesis by a repressor with a very rapid turnover and that induction by hydrocortisone could