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Studies on the Potential of Natural Zeolites and Modified Natural Zeolites Towards the Removal of Heavy Metals from Smoke Cigarette

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In present work, the potential of natural zeolites and modified natural zeolites for removal of heavy metal cations from main stream smoke cigarette are investigated. Different natural zeolites such as clinopeltiolite, analcime, natrolite, perlite, kaolinite and bentonite have been used as filter in the cigarettes for removal of the heavy metal cations, the results have shown these natural zeolites could removed be only 0.5-6.0 % the metal cations from mainstream cigarette. Therefore, these zeolites are modified with different substances in solid and solution state and then the potential of the modified zeolites are examined for removal of heavy metal cations from mainstream smoke cigarette. The results were shown that these modifications are suitable and modified zeolites could be removed from 13 to 47 % of heavy metal cations from mainstream smoke cigarette.

Key Words: Smoke cigarette, Modified zeolites, Removal of hazardous substances.

INTRODUCTION

Numerous studies have been published on the toxicological aspect of cigarette smoking. In order to specify the combustion products of cigarette one has take into consideration that a burning cigarette and tobacco smoke represent a very complex chemical zone reaction with a large number of reaction products. At the present, more than 4700 substances that are known in smoke cigarette and more than 60 of these substances are known to cause cancer in human[1]. Numerous studies have been published on the determination of the metal cations in the smoke cigarette[2]. Because it is possible transfer of certain elements to the human body from main stream smoke cigarette and the most of these cations are toxic, therefore it is necessary to remove these elements from mainstream smoke cigarette. When tobacco cigarettes are burned during smoking, a cycle of combustion

pyrolysis, distillation and nucleation takes place to form the smoke that is drawn into to mouth of the smoker[3]. This mainstream smoke is a mixture of many chemicals in the vapour and particulate phases, such as poly cyclic aromatic hydrocarbons, phenols, aromatic amines, *etc*[4]. These compound are very harmful, therefore decrease of these compounds from mainstream cigarette is necessary. Due to the widespread use of cigarette and other tobacco products, tobacco is considered as one of the most important commodities for human consumption. Because the possible transfer of certain elements to the tobacco smoke during the combustion process[5,6] and the possible formation of toxic and carcinogenic compounds[6,7], it is desirable to study the nature and concentration of various elements present in cigarette tobacco. Such compounds may enter into the human body through the respiratory system *via* smoke inhalation. It is well known that trace metals may play an important role in human metabolism and either an excess or deficiency of certain metals in the organism can lead to biological disorders, which include anemia, some particular forms of cancer and even death[8].

Most of the work concerned with the determination of toxic metals in cigarettes has been carried out using neutron activation analysis. Zeolites, in narrow definition are the porous crystalline aluminosilicates having a uniform pore structure frameworks comprising $[SiO_4]^{4-}$ and $[AlO_4]^{5-}$ tetrahedral units. The atoms (Si, Al) are joined by an oxygen bridge. Thus resulting in the general framework formula $(AlO_2)_x(SiO_2)_{n-x}$, where n is the number of tetrahedral per unit cell and $x < n/2$. Since Aluminum is trivalent, every AlO_2 unit carries a negative charge, which is compensated by a positive charge associated with a cation[9,10]. Zeolites are crystalline aluminosilicates that contain cavities and microporous structure. Therefore, zeolites are extensively used in adsorption, purification processes like gas swettening and air decontamination[3]. Due to unique structural, zeolites and modified zeolites have been utilized for pollution control of heavy metal ions[11], organic pollutants[12], catalyst applications[13], separation processes[14], solid-phase ion exchange[15] and ion selective electrodes[16,17]. In this work, the potential of natural zeolites and modified natural zeolites has been investigated for removal of heavy metal cations from mainstream smoke cigarette. Different zeolites such as analcime, natrolite, perlite, clinopeliolite and clay minerals such as kaolinite and bentonite were investigated. It is found that the natural zeolites removed less than 8 % heavy metal cations from smoke cigarette. Therefore, the zeolites with different modifier substances are used as sorbent for removal of heavy metal cations from mainstream cigarette smoke.

EXPERIMENTAL

The atomic absorption measurements were made on Varian model Spectr AA 220 that equipped with a flame atomizer was used for determination of heavy metals (Table-1).

TABLE-1

	Lead	Cadmium
Wavelength (nm)	217.3	228.8
Lamp current (mA)	11.0	4.0
Slit width (nm)	1.0	0.3
Acetyle flow (L min^{-1})	1.5	1.5
Air flow (L min^{-1})	3.5	3.5

All chemical reagents used were analytical reagent grade. Standard reference solutions for calibration and optimization of the analytical conditions were prepared as follow: Lead nitrate $Pb(NO_3)_2$ and $Cd(NO_3)$ from Merck, were dissolved in double distilled water and diluted to 100 mL flask to give1000 μg/mL Pb(II) and Cd(II).

Analytical procedure

Sampling

Main-stream smoke: The main-stream smoke from two cigarettes, randomly selected from each brand was collected using the assembly shown in Fig. 1. For this purpose cigarettes were sequentially inserted into the internal glass tubing of the assembly and gentle suction was initiated *via* the lateral arm of the external glass cylinder, by means of a vacuum pump. The smokes of two cigarettes were passed through 15 mL concentrated nitric acid. Then the sample was introduced to 25 mL volumetric flask and diluted.

RESULTS AND DISCUSSION

Determination Cd^{2+} and Pb^{2+} in cigarette smoke: The smoke of zar cigarette (an Iranian cigarette) is passed from assembly (Fig. 1) and then the heavy metal cations concentration is determine in the part B that containing 15 mL of HNO_3 (5 mol/L). The results were given in Table-2.

TABLE-2
CONCENTRATION OF Cd^{2+} AND Pb^{2+} IN CIGARETTE SMOKE

Element	Found (μg/cig)
Cd^{2+}	0.87
Pb^{2+}	12.46

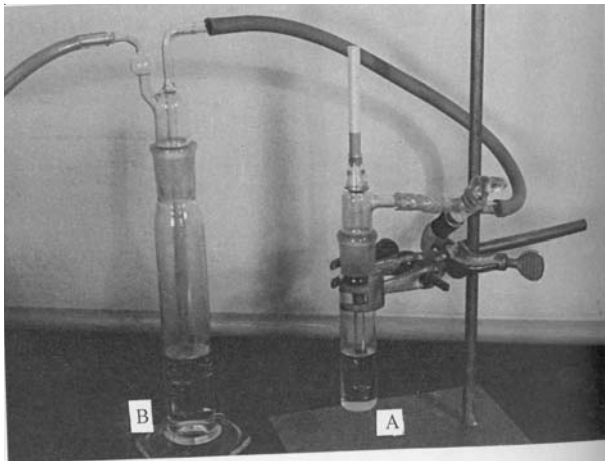

Fig. 1. Assembly used for collection of metals from main-streams smoke

Investigation potential of raw zeolite for removal of cations from main stream smoke: Each zeolite (2 g) is used as filter and then passed the smoke cigarette through it, then finally the smoke was passed in B as shown in Fig. 1. The concentration of cations in the part B was determined. The results are given in Table-3.

TABLE-3
EFFECT OF ZEOLITE FOR REMOVAL OF CADMIUM AND LEAD

Zeolite	Amount (μg/cig)		Decrease amount		Percent (%)	
	Cd	Pb	Cd	Pb	Cd	Pb
Clinopeltiolite	0.82	11.62	0.05	0.84	5.75	6.74
Perlite	0.83	11.69	0.04	0.77	4.60	6.17
Bentonite	0.84	11.80	0.03	0.66	3.45	5.13
Analcime	0.83	11.48	0.04	0.98	4.60	7.90
Natrolite	0.82	11.73	0.05	0.73	5.75	5.85
Kaolinite	0.85	11.96	0.02	0.50	2.30	4.01

Preparation of modified zeolite and investigation potential of modified zeolite: The zeolites are modified with Pd^{2+}, Ni^{2+} and cyclodextrine reagents and used them as filter for adsorption of hazardous material from smoke cigarette. The results were shown in Table-4.

Conclusion

A selective and sensitive method is proposed for the removal of harmful material from smoke of cigarettes. The results showed that the raw aluminusilicate is not found suitable for cigarette filters but modified aluminosilicate can be used as filter for decrease of heavy metal ions from cigarette smoke.

TABLE-4
EFFECT OF MODIFIED ZEOLITE FOR REMOVAL
OF CADMIUM AND LEAD

Modifier	Zeolite	Amount (μg/cig)		Decrease amount		Percent (%)	
		Cd	Pb	Cd	Pb	Cd	Pb
Cyclodextrine	Clinopeltiolite	0.47	6.95	0.40	5.59	46.00	44.22
Pd^{2+}	Clinopeltiolite	0.62	9.03	0.25	3.43	28.75	27.59
Ni^{2+}	Clinopeltiolite	0.70	6.50	0.17	2.96	19.55	23.75
Cyclodextrine	Perlite	0.48	7.75	0.39	4.71	44.85	37.80
Pd^{2+}	Perlite	0.68	9.26	0.19	3.20	21.85	25.68
Ni^{2+}	Perlite	0.71	9.75	0.16	2.71	18.40	21.74
Cyclodextrine	Bentonite	0.59	7.83	0.28	4.63	32.20	37.15
Pd^{2+}	Bentonite	0.64	9.43	0.23	3.03	26.45	24.31
Ni^{2+}	Bentonite	0.71	10.20	0.16	2.26	18.40	18.13
Cyclodextrine	Analcime	0.46	7.89	0.41	4.57	47.15	36.67
Pd^{2+}	Analcime	0.66	9.21	0.21	3.25	24.15	26.08
Ni^{2+}	Analcime	0.70	10.02	0.17	2.44	19.55	19.58
Cyclodextrine	Natrolite	0.54	7.11	0.33	5.35	38.00	42.93
Pd^{2+}	Natrolite	0.71	9.31	0.16	3.15	18.40	25.28
Ni^{2+}	Natrolite	0.72	9.66	0.15	2.80	17.25	22.47
Cyclodextrine	Kaolinite	0.64	10.23	0.23	2.23	26.43	17.89
Pd^{2+}	Kaolinite	0.75	10.80	0.12	1.66	13.80	13.32
Ni^{2+}	Kaolinite	0.78	11.68	0.09	0.78	10.35	6.26

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