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Research Article

Adsorption and Desorption of Major Gases on Some Clays Obtained by Heating Tobacco at Certain Temperatures

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Abstract

The tobacco roasting-process was carried out and a study was carried out on the composition of the gases released during this process. It has been determined that the amounts of substances obtained from the studied tobacco are generally less than the amounts of substances obtained in the literature. The volatile gases formed during this roasting were passed over some clay minerals and adsorbed on them. The adsorbed components were desorbed by diethyl ether extraction. Adsorption and desorption analyzes were investigated by GC and TG techniques. The components released during the tobacco-roasting process were first directly obtained and analyzed by gas chromatography. Then, the adsorbing efficiency to clay for each of the components in the vapors from tobacco was calculated by comparing the amount of the component retained in the absence of adsorbent with the amount retained after the component was passed over the adsorbent. The structure of the clay samples used as adsorbent was investigated by chemical analysis and DTA techniques. The adsorption efficiencies are discussed with the physical properties of the clays, the affinities of the volatile components, and their adsorption efficiency. Most of the volatiles adsorbed on the adsorbents were recovered by diethyl ether extraction. Especially benzaldehyde, propionic acid, furfuryl alcohol, 3-methylbutanoic acid and nicotine were recovered with good yield.

Keywords: Tobacco-roasting volatiles, clay minerals, adsorption, desorption

INTRODUCTION

Thousands of compounds have been identified in tobacco and tobacco smoke, and many still remain to be identified. The substances that make up the tobacco leaf can be divided into two groups as organic and inorganic compounds (Delbert 1990). Organic materials burn to form smoke and inorganic materials form ash. Potassium and calcium are the most abundant of the inorganic compounds in tobacco. In addition, there are Mg, Fe, P, Si, Cl and many trace elements and their oxides. The main organic substances in tobacco are: Hydrocarbons, nitrogenous compounds (especially nicotine, alkaloids, proteins, amino acids and nitrates), carbohydrates (sugars, starch, cellulose and organic acids), other compounds (pigments, polyphenols, carbonyls, fatty acids, resins, waxes and sterols). There are many hydrocarbons in tobacco, including paraffin, aromatic and terpenic hydrocarbons. Hydrocarbons are found together with substances that accumulate on the leaf surface and are expressed by the common term ESC (ether-soluble compounds), and normal and iso-paraffins with carbon numbers from 25 to 33 have been detected (Stedman 1968). The quality of tobacco is determined by the chemical composition of the leaf and the resulting smoking characteristic. The smoothness of the smoking feature is possible with the high burning rate of the cigarette and the low levels of harmful substances such as tar, nicotine, CO, H_2S (hydrogen sulfide), NCH (hydrocyanic acid) in the smoke. Potassium and chlorine content of tobacco are the factors that play a prominent role in the relationship between chemical composition and burning ability and have been emphasized by many researchers until today (Çağlar 1989). Adsorption power and rheological properties of clays are taken into consideration in almost all usage areas (Bonilla et al. 1981, Bozdogan 1990). Chemical analyzes have shown that the clays are aluminum silicate compounds with high water holding and ion exchange strengths. Clays are classified in different ways according to their geological formation, physical properties, chemical properties and usage areas (Norton 1974). The industrial importance of kaolin and bentonite clays is very complex (Clarke 1989). Clays whose main mineral is kaolinite, halloysite or a mixture of both are called kaolin. The structural structure of kaolinite, whose general formula is $Si_4Al_4O_{10}(OH)_8$, is revealed by the combination of a silicon tetrahedron layer and an aluminum octahedron layer. In this respect, clay minerals of the kaolinite group are also called 1:1 type. The top of silicon tetrahedrons and all ends of aluminum octahedrons are in the same direction and toward the center of the surface formed by the silicon and aluminum layers. There are mica, quartz, cristobalite, feldspar, alunite, smectite and various forms of iron and titanium oxide as impurities in kaolin (Cole et al 1971, Bell 1976, Jepson 1984, Kuzvart 1984, Petterson and Murry 1984). By being activated with acids, bases, salts and various organic substances, the properties of some bentonites are further improved. The adsorbing power of inorganic and organic molecules and ions of Ca-bentonite, ara-bentonite, and metabentonite activated by treatment with hydrochloric acid or sulfuric acid increases. Ca-bentonites are reversibly converted to Na-bentonites by treatment with a strong base such as sodium hydroxide or a basic salt such as Na_2CO_3 (Koster van Gross and Gugenheim 1989). During the treatment of Na-bentonites with organic materials, rather large organic molecules enter between the layers of smectite minerals and change the rheological, adsorption and catalytic properties of bentonites (Reichle 1985, Carrado et al. 1986: Suzuki et al. 1988, Singh and Kodama 1988, Lee and Selin 1989). Organoclays or organobentonites whose layers diverge greatly from each other with the introduction of organic molecules are called "pillared clay" (Barrer 1989). The adsorption power of bentonites is due to interparticle and intraparticle porosity. Bentonites contain all kinds of pores. Adsorption properties such as surface area, micro- and mesopore volumes, as well as micro- and mesopore size distributions are generally determined with the help of adsorption and desorption isotherms of nitrogen at 77K (Sarıkaya and Ambar 1978). The specific surface area of bentonites is generally determined by the standard BET method (Brunauer et al. 1938). Bentonites, whose natural and porous structure can be changed by acid or soda activation, are of great importance in the chemical, paper and detergent industries (Laszlo 1987). Refining of sulfur, production of herbicides, production of creams and cosmetics, production of electrodes and diaphragms, soap production, cleaning of drinking water and waste water, palletizing of coal dust and metal ores, extinguishing forest fires, oil removal on water, catalyst production, rubber and plastic Bentonites are used significantly in processes such as production and removal of radioactive materials (Heyding et al. 1960, Tamura and Struxness 1963, Yamanaka and Brindly 1979, Sarıkaya et al. 1982, Fritz 1986, Wanner 1987). For this reason, this study was carried out to remove some substances in tobacco before making cigarettes or to find an adsorbent substance (as a filter) that will adsorb these substances during smoking. Therefore, first of all, some substances in the tobacco of our region (Bitlis, Muş, Turkey) were determined and it was investigated which of the identified harmful substances were attached to which adsorbent and at what rate.

MATERIALS and METHOD

Adsorbents: Küçükgök Village clay, Kütahya bentonite, Iznik clay and Mezardere clay were used. Before using these adsorbents, they were ground in a mortar after acid activation and passed through a 400 mesh sieve. 0.5g and 1g were taken from each sieved adsorbent.

Acid Activation of Adsorbents: Samples taken from adsorbents were activated in accordance with the wet method by boiling with 0.75M HNO_3 solution for 1 hour. The samples taken from the solution by filtration were dried at room temperature (18°C) without washing (Ceylan and Sarıkaya, 1989).

Chemical analysis of adsorbents used: The original clay samples were analyzed with a standard method applied to silicates (Ewing 1975, Bozdoğan 1990). A sample of clay, all of which had been ground through a 0.038mm (400mesh) sieve, was held in an oven set at 105°C until it reached constant weight, and the mass reduction was evaluated as 'moisture'. The carbonate in some clay samples was washed with dilute hydrochloric acid and removed before moisture determination. After a certain mass sample taken from carbonate and moisture-removed clay was heated at around 100°C for a certain period of time, the mass reduction determined was taken as the glow loss (loss on ignition, LOI). SiO_2, Al_2O_3, Fe_2O_3, TiO_2, CaO, MgO in the remaining sample. The percentages of Na_2O, and K_2O were determined by applying wet analysis and spectrophotometry methods. The chemical analysis results of the clay samples used are shown in Table 1. The metal amounts in the clay are given as percentages to the metal oxide.

Table 1. Chemical Analysis of Clay Samples

composition	**Kütahya Bentonite**	**İznik Bentonite**	**Mezardere Kaolin**	**Küçükgök Clay**
LOI*	7.50	6.40	10.05	6.25
SiO_2	71.90	73.40	63.36	65.35
Al_2O_3	13.85	13.60	25.70	22.90
Fe_2O_3	0.68	1.90	0.11	0.89
TiO_2	0.09	0.30	0.21	1.13
CaO	2.42	1.70	0.18	0.29
MgO	1.27	0.80	0.12	0.62
Na_2O	0.39	0.90	0.12	0.39
K_2O	1.62	0.80	0.15	1.93

* Loss on Ignition

DTA Thermograms: DTA thermograms from room temperature to 1050°C with a heating rate of 10°C/min and a paper speed of 3mm/min in a nitrogen atmosphere (flow rate of 50ml/min) by taking approximately 10mg from each sample (ΔT-T curves) were determined. α-alumina was used as inert material during DTA. In order to see the DTA peaks more sharply, the clay sample, which was finely ground to pass through a 0.038 mm sieve, was filled into the platinum heating capsule. In order to increase the thermal conductivity by disappearing the spaces between the particles, the samples whose capsule is filled are compressed as much as possible. DTA thermograms of pure clays are given in figures 3 and 4.

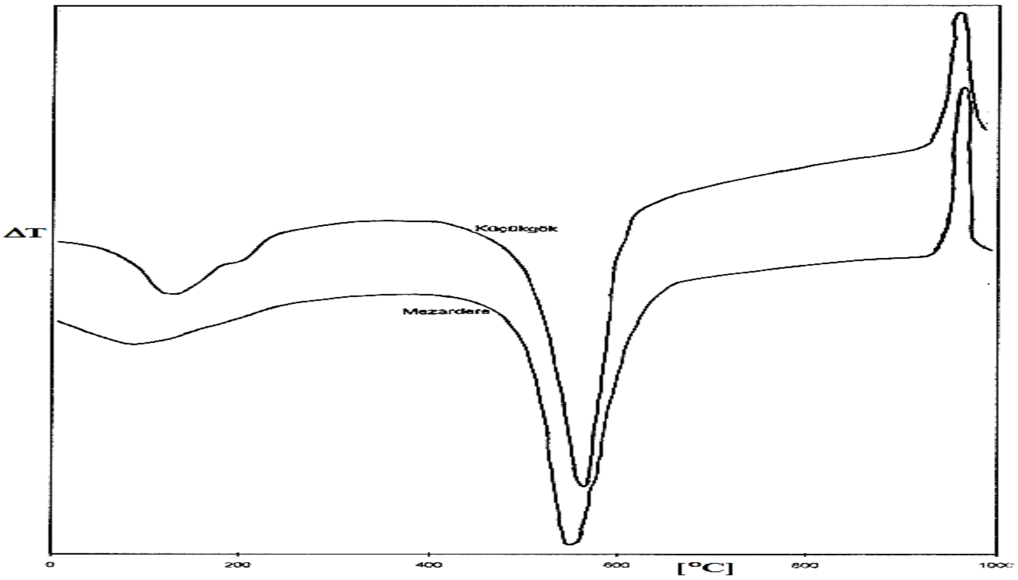

Figure 1. DTA Thermograms of Pure Küçükgök Clay and Pure Mezardere Kaolinite

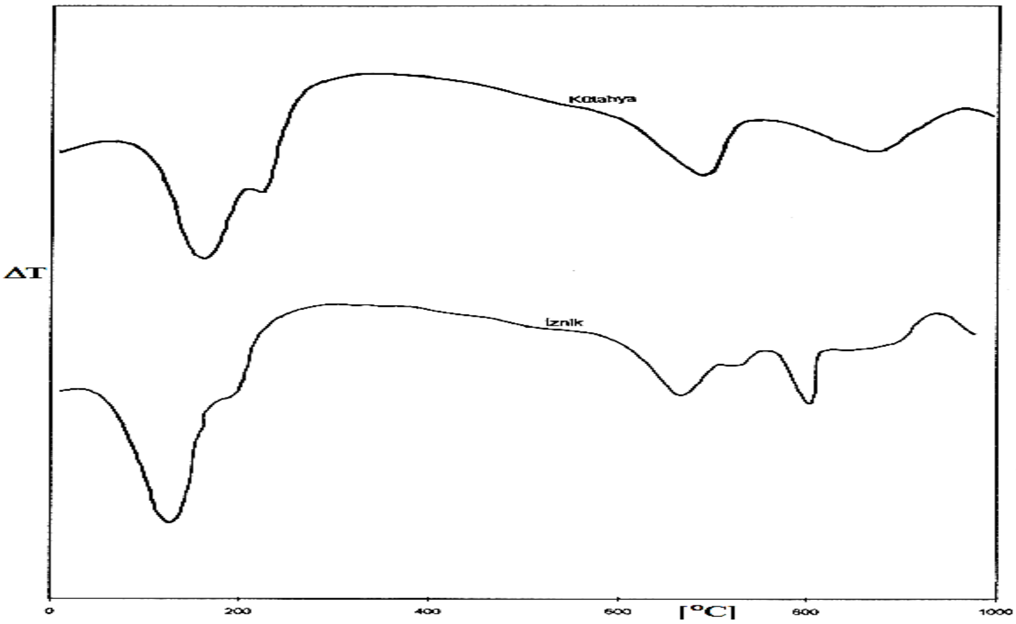

Figure 2. DTA Thermograms of Pure Kütahya and Pure Iznik Bentonites.

TG thermograms: Thermograms were taken using a Shimadzu TGA-H50 instrument, giving the variation of the decomposition rate versus temperature from room temperature to 820°C, in a nitrogen atmosphere with a heating rate of 10°C/min. TG graphs of pure (acid-treated) and adsorbed clays (İznik, Küçükgök clay, Kütahya and Mezardere) were taken and these curves are given in Figure 5 (only one clay's TG thermogram is given here)

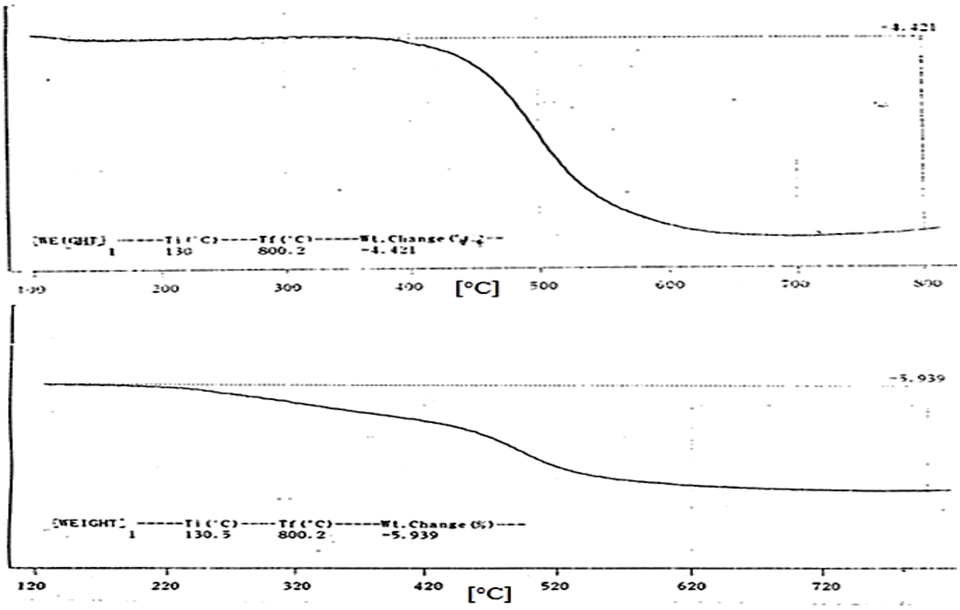

Figure 3. TG Thermograms of Pure (upper curve) and Adsorbed (lower curve) Küçükgök Clay

Tobacco material: Bitlis and Muş region tobacco cut into 1mm wide fibers were used. Tobacco materials were conditioned in a room at constant temperature and humidity (22°C, 46% RH). For adsorption, processed (a blend of Bitlis and Muş region tobaccos enriched with volatiles released in the roasting process) tobacco was used.

Roasting Procedure: 50g of tobacco material was placed in a flat bottom 1000 ml flask. The balloon was heated in a drying oven at 100°C and 150°C. The volatiles from the heated tobacco were sent to a U-shaped glass tube (Figure 1) cooled in a liquid nitrogen bath at a flow rate of 100ml/min (with carrier nitrogen gas). The schematic flow is shown in Figure 2. In this way, the condensate accumulated in the glass tube was prepared for GC analysis (Matsukura et al. 1983,1984).

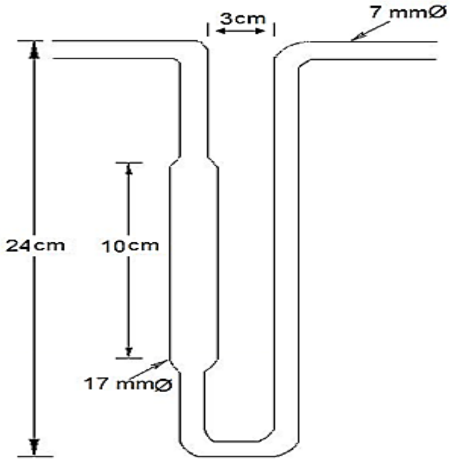

Figure 4. U-shaped glass tube

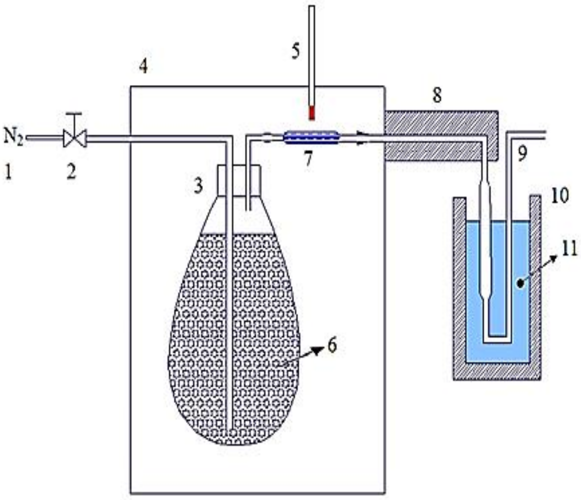

Figure 5. Apparatus for Tobacco Roasting
1: carrier gas, 2: flow controller, 3: glass balloon, 4: drying oven, 5: thermometer, 6: tobacco material, 7: adsorbent column, 8: thermal insulation, 9: U-shaped glass tube, 10: Dewar container, 11: liquid nitrogen.

Adsorption: 50g of processed tobacco (a blend of Bitlis and Muş region tobaccos enriched with volatiles released in the roasting process) was placed in the balloon inside the oven; oven temperature was set to 150°C. The volatiles were sent to the U-shaped glass tube cooled in a liquid nitrogen bath with carrier nitrogen gas (at a rate of 100 ml/min) after passing through a column (6mm i.d.x80mm) in which 0.5g adsorbent was placed. The clays adsorbed in this way and the liquid condensed in the U-shaped glass tube were taken and made ready for the related analyzes (Matsukura et al. 1984, 1985).

Adsorption efficiency (μ_Z) for each of the components in the vapors from the roasted tobacco was calculated with the formula $\mu_Z = \frac{Z_1 - Z_2}{Z_1} x100(\%)$. Here, Z_1 is the amount of any Z component retained in the U-shaped pipe when there is no adsorbent in the medium; Z_2 is the amount of Z component retained in the U-shaped pipe after it is passed over the adsorbent.

Sample preparation for gas chromatography: The condensate collected in the U-shaped glass tube was washed with 20ml dichloromethane and transferred to a clean 200ml Erlenmayer bottle containing the internal standard compound (n-eicosane, about 1mg). Sufficient anhydrous sodium sulfate was added for adsorption of the water layer. In order to break up the solid salt formed during this time, it was stirred for 1 hour with a magnetic stirrer. This dichloromethane solution was transferred to another flask. Then the remaining substances in the Erlenmeyer flask were shaken with 10 ml of dichloromethane. The two dichloromethane solutions were combined and concentrated to approximately 0.26ml with a distillation column (15mm d.x.7cm, filled with cullet) in a water bath heated at 55°C. This concentrated dichloromethane solution was then subjected to GC analyses.

All GC chromatograms were obtained with a GC-14A gas chromatograph, a capillary glass column (0.33mm i.cx25m) coated with PEG 20M, nitrogen as carrier gas (1ml/min), temperature set to 240°C with a FID detector. was done. Thermograms were taken under conditions selected with an oven temperature program set from 60 to 200°C at a speed of 2°C/min and paper speed of 3mm/min. GCs of the condensate of the substances from Bitlis and Muş region tobacco heated at 100°C and 150°C were taken (related chromatograms are not given in this article), the components determined from them and the relative amounts of those components are given in Table 2. For this, the relative concentrations of the compounds were calculated on the basis of the assumption that the peak areas obtained depending on the internal standard have the same sensitivity for each component FID (Matsukura et al. 1986). Accordingly, in any chromatogram of the GC, retention time, peak area and concentration percentages are available for each substance in the analyzed sample. A certain amount of internal standard was added to the sample to be analyzed and subjected to GC. In the chromatogram obtained in this way, the relative percent compositions of the internal standard and all other substances and their amounts with a simple proportion were obtained (Table 2).

Table 2. Components Identified in the volatiles from Roasted Tobacco

Retention Time (s)	Compound	Yield (µg/50g tobacco material)			
		Bitlis[a]		Muş[b]	
		100°C	150°C	100°C	150°C
13	Pyridine	0.00	0.34	0.11	0.16
19	Acetol(1-Hydroxy-2-propanone)	0.51	0.30	0.07	0.15
26	Acetic acid	0.00	0.11	0.00	0.03
28	2-Furfiral	1.00	0.56	0.94	0.46
31	2-Acetylfuran	0.00	0.07	0.14	0.07
32	benzaldehyde	0.00	7.12	0.28	1.70
35	propionic acid	1.78	1.70	1.37	5.21
37	5-Methylfriftral	0.00	0.29	0.30	0.07
41	γ-Buthyrolactone	0.00	0.31	0.12	0.11
43	Furfiryl alcohol	0.59	1.15	0.97	0.37
49	3-Methyl butanoic acid	5.46	6.37	3.71	2.22
52	Benzyl alcohol	98.21	10.04	0.53	3.57
53	Nicotine	148.22	176.66	139.99	89.24
55	n-eikosan[c]	20.00	20.00	20.00	20.00

[a] Bitlis Hizın Sırmaçek Village, [b] Muş Ahçivan Village, [c] Internal standard (0.02mg)

Desorption by ether extraction: 0.5g samples were taken from each of the adsorbed adsorbents (Kütahya, İznik, Mezardere and Küçükgök clays) and placed in a Sokselet device in a cartridge. These were extracted with diethyl ether for 20 hours each. After adding the internal standard compound to this extract, it was concentrated in the same manner as described above. This solution was also subjected to GC analysis. The gas chromatography conditions were the same as described above (Matsukura et al. 1985). Chromatograms related to the adsorption of volatile substances on the clays and the recovery of these substances by ether extraction desorption are given in Figures 6-9. In these figures, **C** shows the GC chromatograms of the condensate obtained in the U-shaped tube in the absence of adsorbent in the tobacco roaster. **A** is the GC plots of the condensate obtained in the U-shaped tube with the adsorbent in the tobacco roaster. **D**'s shown in the figures are GC graphs of the extract obtained from the extraction of adsorbents with diethyl ether over a 20 hour period.

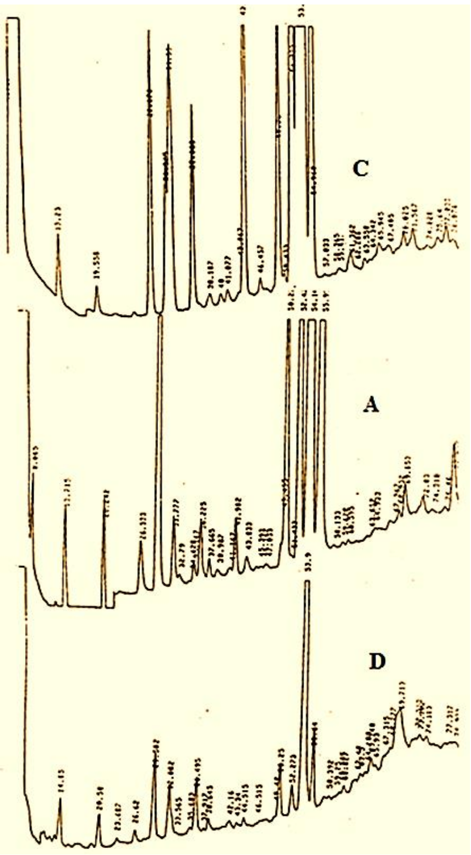

Figure 6. Gas Chromatograms of Condensates of C, A and D.
C: Condensate in the U-shaped glass tube without *İznik Bentonite* column. **A**: Condensate in the U-shaped glass tube with *İznik Bentonite* column. **D**: Volatiles extracted continuously by diethyl ether for 20 hr from *İznik Bentonite*.

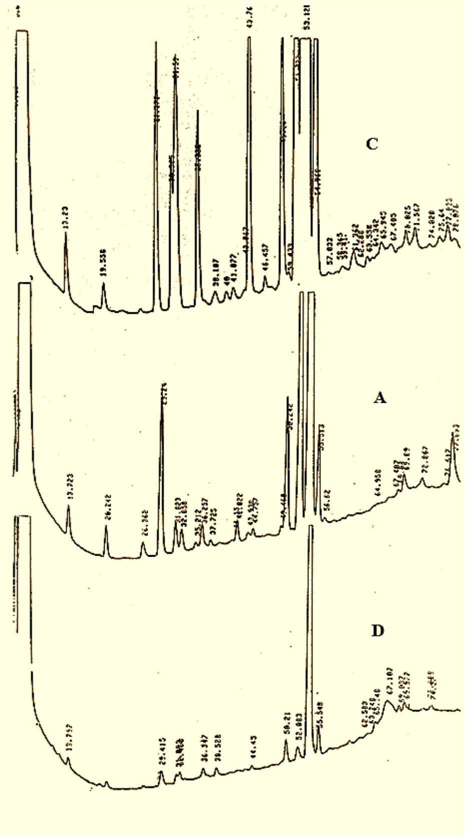

Figure 7. Gas Chromatograms of Condensates of C, A and D.
C: Condensate in the U-shaped glass tube without *Küçükgök Clay* column. **A**: Condensate in the U-shaped glass tube with *Küçükgök Clay* column. **D**: Volatiles extracted continuously by diethyl ether for 20 hr from *Küçükgök Clay*.

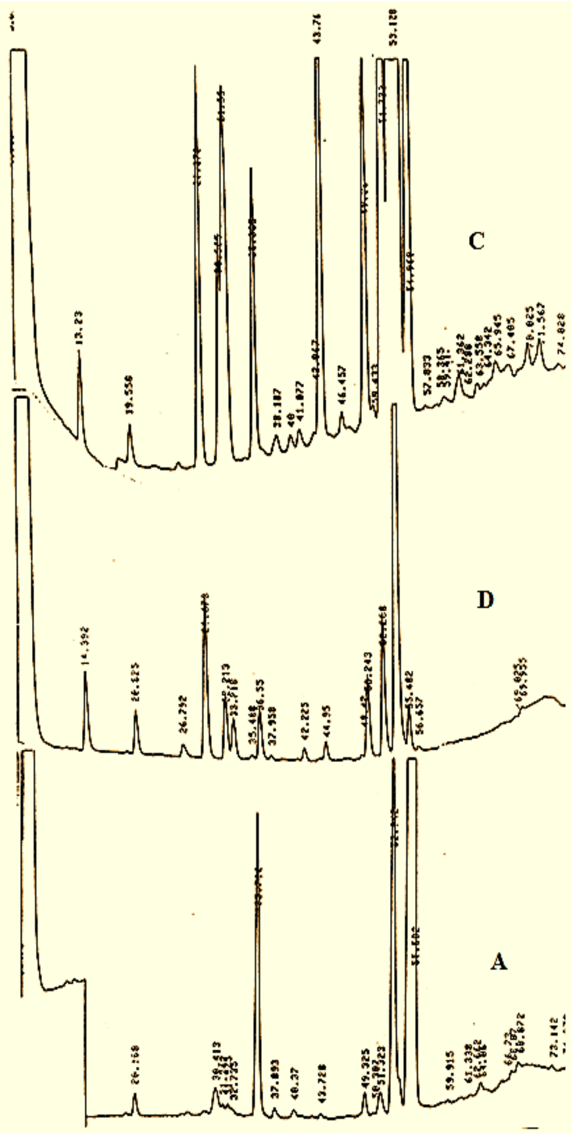

Figure 8. Gas Chromatograms of Condensates of C, A and D.
C: Condensate in the U-shaped glass tube without *Kütahya Bentonite* column. **A**: Condensate in the U-shaped glass tube with *Kütahya Bentonite* column. **D**: Volatiles extracted continuously by diethyl ether for 20 hr from *Kütahya Bentonite*.

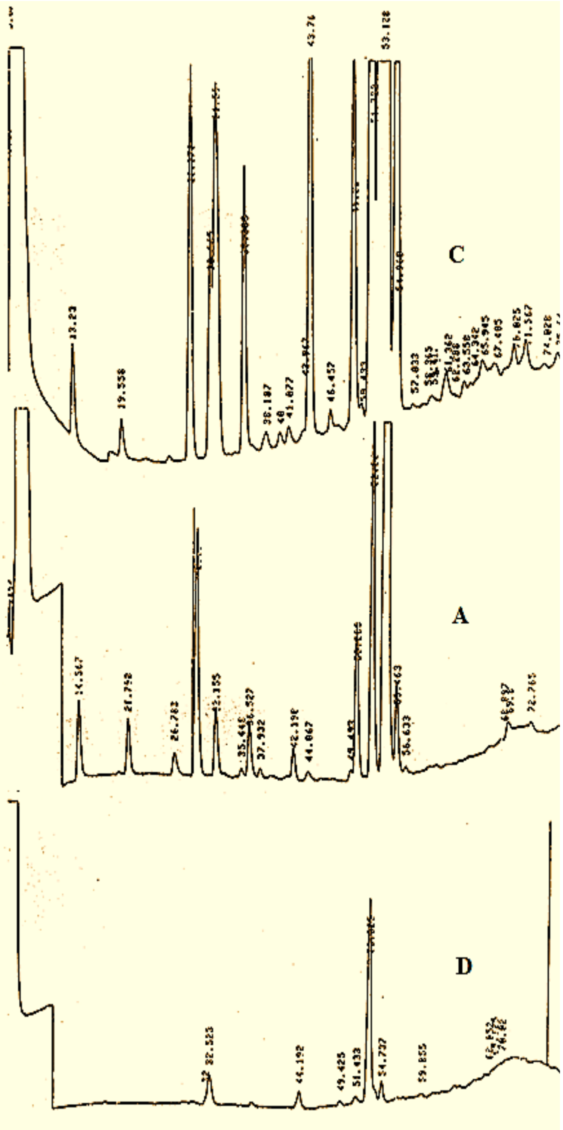

Figure 9. Gas Chromatograms of Condensates of C, A and D.
C: Condensate in the U-shaped glass tube without *Mazardere kaolin* column. **A**: Condensate in the U-shaped glass tube with *Mazardere kaolin* column. **D**: Volatiles extracted continuously by diethyl ether for 20 hr from *Mazardere kaolin*.

The amounts of adsorbed and desorbed substances were determined by using GC chromatograms of A (adsorption) and D (desorption) condensates. The substance amounts were calculated by simple proportion from the known amounts of the internal standard and the percent concentrations given in the chromatograms of each sample. While the adsorption efficiency of each component in the volatiles from the heated tobacco on the adsorbents is given in Table 3, the amounts of volatiles recovered by ether extraction desorption are shown in Table 4.

Table 3. Clays adsorption efficiency of each component in volatiles from roasted tobacco

Retention Time (s)	Compound	Control (μg/50 g of tobacco)	Adsorption efficiency of the adsorbents, μ_A(%)			
			İznik	Küçükgök	Küyahya	Mezardere
13	Pyridine	76.5	21	25	9	4
19	Acetol(1-Hydroxy-2-propanone)	339.4	79	84	89	85
26	Acetic acid	İz	#	#	#	#
28	2-Furfiral	342.2	4	3	56	23
31	2-Acetylfuran	172.6	100	67	66	100
32	Benzaldehyde	479.4	91	90	92	87
35	propionic acid	250.9	96	95	99	97
37	5-Methylfriftral	205.8	95	95	98	96
41	γ-Buthyrolactone	191.3	84	97	100	100
43	Furfiryl alcohol	513.7	97	97	97	95
49	3-Methyl butanoic acid	384.8	98	97	99	98
52	Benzyl alcohol	1694.2	70	34	93	77
53	Nicotine	12874.0	74	55	95	76

The value of μ_Z is minus (-) or a number can be divided by zero, so $\mu_Z=(0-Z_2)/0$!

Table 4. Amounts of materials recovered by ether extraction from clays

Retention Time (s)	Compound	Control (μg/50 g of tobacco)	Ether extract, (μg)			
			İznik	Küçükgök	Küyahya	Mezardere
13	Pyridine	76.5	11.7	5.4	0.0	0.0
19	Acetol(1-Hydroxy-2-propanone)	339.4	9.0	0.0	5.9	0.0
26	Acetic acid	İz	3.1	0.0	0.0	0.0
28	2-Furfiral	342.2	25.6	10.7	0.0	0.0
31	2-Acetylfuran	172.6	0.0	5.6	11.7	0.0
32	Benzaldehyde	479.4	19.2	6.5	3.4	34.0
35	propionic acid	250.9	19.4	5.6	89.5	0.0
37	5-Methylfriftral	205.8	16.3	5.1	2.7	0.0
41	γ-Buthyrolactone	191.3	25.9	0.0	2.0	0.0
43	Furfiryl alcohol	513.7	1.2	867.6	1.0	183.1
49	3-Methyl butanoic acid	384.8	0.8	15.5	6.5	4.3
52	Benzyl alcohol	1694.2	0.0	11.5	8.4	0.0
53	Nicotine	12874.0	225.2	497.7	132.3	245.3

RESULTS and DISCUSSION

Changes in the adsorbing properties of clays with acid activation, changes in the chemical and mineralogical structure of the clay, depending on the acid ratio in activation, affect the particle size distribution, specific surface area, specific pore volume, pore size distribution and bleaching power. During the acid activation, the specific pore volume increases due to the pores opened in the places of the metallic cations that move away from the minerals in the clay. The specific pore volume is slightly increased due to the micropores that are initially opened. However, due to the large number of walls that these micropores have, the specific surface area increases more. As the activation progresses, mesopores are formed by the destruction of the walls between the micropores due to the cations that move further away. Meanwhile, while the specific pore volume continues to increase, the increase in the specific surface area first slows down and then stops, as some of the walls disappear. As the activation progresses, the disappearance of most of the micropores, as well as the destruction of the walls between the mesopores and the formation of macro pores, causes the specific surface area to decrease while the specific pore volume continues to increase. Activated soils with different properties can be produced by changing the type of clay, acid used, acid ratio, activation temperature and activation time. It has been concluded that adsorbents with the desired specific surface area can be prepared with acid activation within certain limits. The first endothermic peak, which is at temperatures lower than 300°C in the DTA curves of the pure state of the clays used as located adsorbent (Figures 3-4.), results from the removal of water between the layers of the clay minerals. Endothermic peaks observed between 400°C and 900°C temperatures indicate that the -OH groups in the crystal structure are removed. Endothermic peaks observed between 400°C and 900°C temperatures indicate that the -OH groups attached to the crystal structure are removed. Concentrations of non-clay minerals such as calcite, dolamite and magnesite between 700°C and 900°C also cause endothermic peaks. The shapes of the endothermic peaks caused by the removal of both water and -OH groups and their locations in the DTA curve provide practical information about the mineralogical structure and some properties of the clays. The size of the water peak area indicates that the clay holds water to a large extent that this peak extends up to around 400°C, it is a very swelling clay, and the same peak is a fork, which indicates that the clay contains two different clay minerals. In the clays used, the peak area decreases in the order of Kütahya bentonite, İznik bentonite, Küçükgök clay and Mezardere kaolin. According to this, the least water retaining is Mezardere and the most water retaining Kütahya bentonite. Exothermic peaks observed when the temperature is increased above 900°C are due to the decomposition of the crystal structure of clay minerals and the formation of new phases that are not clay minerals. TG remograms of pure and adsorbed Küçükgök clay are given in Figure 5. TG thermograms of other clays (İznik, Kütahya and Mezardere) were also taken in the same way (they are not given in this article). The weight loss of pure and adsorbed TG temograms between 130°C and 800°C is shown on the figure. While the mass losses seen in the pure state of the clays at low temperatures are caused by the water bound in the structure in various ways, mass losses are added in the adsorbed clays as a result of the removal of the adsorbed materials. Therefore, the mass loss of the adsorbed form is higher in all adsorbents except Mezardere clay. The fact that the weight loss of Mezardere clay after adsorption is less than its pure form shows that this clay adsorbs little or no substance. This can be attributed to the clay mineral (kaolin) in the clay's structure. Among the clays subjected to adsorption, the mass loss is mostly seen in Kütahya bentonite. While the total mass loss of pure Kütahya bentonite between 130°C and 800°C is 2.038%, the mass loss between the same temperatures after adsorption is 4.358%. The weight losses of the pure and adsorbed forms of other clays between 130°C and 800°C are as follows, respectively. Iznik: 4.613%, 5.589%; Küçükgök: 4.421%, 5.939%; Kütahya: 2.038%, 4.358% and Mezardere: 10.41%, 9.619%. The difference between these mass losses shows the total amount of material retained in the adsorbents. The components identified using the GC chromatograms of the condensate of substances from tobacco heated at 100°C and 150°C and their relative amounts are given in Table 2. Relatively small amounts of sugar pyrolysis products (low-boiling carbonyl compounds, furans, and lactones) as well as lower fatty acids and components of essential oils were found from the volatiles from the heated tobacco. As can be seen in Table 2, thermal degradation products of sugar analogs, namely acetol, 2-furfural, 2-acetylfuran, benzaldehyde, 5-methylfurfural and furfural alcohol, fatty acids such as acetic and propionic acids, and nitrogenous compounds pyridine and nicotine were also found. The volatiles from the roasted tobacco of Bitlis Sırmaçek village and Muş Ahçivan village tobacco are mostly nicotine and benzyl alcohol. Volatiles from tobacco roasted at 100°C gave a characteristic tobacco odor. It was observed that the amount of volatiles was slightly higher in Bitlis Sırmaçek village tobacco compared to Muş Ahçivan tobacco roasted at the same temperature (Table 2). It is known that a higher temperature increases thermal decomposition reactions (such as the thermal decomposition of sugar), and large molecular compounds are converted to compounds with lower molecular weights by oxidative decomposition (Matsukura et al. 1983). Volatiles occurring at 150°C are generally more than those formed at 100°C. However, it is seen that the amounts of some substances obtained at 150°C are less than those obtained at 100°C. This may be due to the fact that the released substances react with each other and turn into other substances. It was observed that the condensate obtained from tobacco heated to 150°C had a stronger burnt sugar-like and characteristic tobacco odor than the condensate obtained from tobacco heated to 100°C. The GC chromatograms of the condensate obtained after the adsorption of tobacco volatile substances and the condensate obtained by ether extraction desorption are given in Figures 6-9. Adsorption percentages of each component of tobacco volatiles on clays are given in Table 3, while the amounts of components recovered by ether extraction desorption are shown in Table 4. When the GC chromatograms related to adsorption and ether extraction desorption are examined, it is seen that the intensity of the peaks from 31 to 49 in the retention time of Iznik bentonite is greatly reduced (Figure 6). In other clays, the intensities of the peaks with a retention time of 31 to 49 for Küçükgök clay, 35 to 53 for Kütahya bentonite, and 31 to 53 for Mezardere kaolin are seen to be greatly reduced. In other words, the adsorbability of these substances for these clays is high. In the study on the adsorption and desorption of volatiles on clays, which are formed by tobacco roasting and can be used as cigarette flavoring agents, we can say that the substance with the highest adsorbing efficiency among all adsorbents is 5-methyl furfural with a retention time of 37 (Table 3). The amount of this substance recovered from the adsorbents by diethyl ether extraction is quite low (Table 4). It is seen in Table 3 that the adsorption abilities of substances with both retention times greater than 31 and molecular weights greater than 100 (except benzyl alcohol) on all adsorbents are the highest. Furans with a molecular weight greater than 100, 2-acetylfuran and 5-methylfurfural have greater adsorption ability than others. Also, acetol (1-hydroxy-propanone), an aliphatic ketone, has been adhered to almost the same degree. The adsorbing ability of pyridine and 2-furfural is less than other substances. It was observed that acetic acid adsorbed very little on the adsorbents. On the other hand, it was determined that the amount of acetic acid in the products increased after passing through the column containing the adsorbent. It is shown that this acid is formed on the adsorbent as the vapors from the roasted tobacco pass through the adsorbent column. It is thought that some of the acids may be formed as a result of oxidation decomposition as the steam heated at 150°C passes over the adsorbents. It has been observed that the ability of benzyl alcohol to adsorb on clays is not low. The recovery of volatiles in adsorbents by ether extraction desorption can be seen in the corresponding GC chromatograms (Figures 6-9 desorption), sugar analogues thermal degradation products, 2-furfural, 2-acetylfuran, 5-methyl-furfural, γ-butyrolactone and furfiryl alcohol were obtained as the main substances. Recovered amounts of 2-furfural, 2-acetylfuran and γ-butyrolactone were found to be very low (Table 4). It was observed that the adsorption of 5-methyl furfural is good and its recovery by ether extraction desorption is also quite difficult. At the same time, it is seen that the desorption of substances that adsorb at a lower rate such as nicotine is easier than the first (Tables 3,4). Although the adsorption efficiency of benzyl alcohol for İznik and Mezardere clays is high, its recovery by desorption is very low. This is very suitable for adsorption rules. Of course, desorption of the more strongly adherent material will be difficult.

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