DISTINGUISHING CHARACTERISTICS FOR PARTICULATE CARBONACEOUS MATERIALS DISCHARGED IN THE ATMOSPHERE BY FUEL BURNING SOURCES

SIDNEY BLOOMENTHAL, *University of Chicago*

AND

ISADORE DEUTCH, *Chicago Department of Smoke Inspection and Abatement*

During the past fifty years most large cities in the midwest have been trying to keep the air clean for their citizens. Until very recently these attempts have been confined mainly to efforts on reduction of visible smoke, the source of which is easily determined.

However, during the past decade or two, the attention of municipal authorities has been directed to contamination of the air from fuel burning plants that appear to the naked eye to be operating with clean chimneys. One such form of contamination is the discharge of particulate carbonaceous materials and ash from chimneys. The introduction and acceptance by fuel users of the forced draft stoker has resulted in the reduction of visible smoke but has confronted municipal authorities with the problem of excessive solids being discharged into and subsequently settling out of the atmosphere. These solids are often discharged from stacks not emitting any visible smoke. The need for a method of linking carbonaceous material and ash (either entrained in or settling out of the atmosphere) with the source is very urgent. Simply stated, there is a real need for a method of "fingerprinting" the source of dust.

This paper presents some of the work done to date by the authors in attempting to find a practical field method for determining the source of particulate carbonaceous materials and ash. Impetus has been given to this work by the general recognition of the injurious effects for which excess dust in the atmosphere is responsible. The cost of cleaning and decorating the interior walls and ceilings of an apartment house in Chicago exceeds the annual fuel bill, according to the experience of one of the writers. People who live in towns outside of Chicago find it necessary to do the corresponding work but once in four or five years. Schurer[1] examined the lungs of dead people in Pittsburgh and stated that the effect of solid atmospheric contaminants upon health cannot be ignored.

It is my purpose to discuss studies made in collaboration with Mr. Deutch on dust collected out of the gaseous discharge of fuel burning plants in industrial establishments.

Precipitation of dust from flue gas.—The equipment for precipitating dust out of flue gas has been described recently.[2] It consists of a series of impinger bottles with associated measuring devices for determining the volume of gas sampled at precisely the same velocity in the collecting nozzle as in the furnace breeching. Each bottle removes the same fraction of the incoming dust as the preceding one, and with six bottles in the train, the quantity precipitated exceeds 95 per cent of the total entering the nozzle. Unique features of this sampling method are (1) Constant resistance to the flow of gas is maintained throughout the run; (2) With a 0.657 inch diameter sampling nozzle, quantities as large as 10 grams can be collected in a five hour run. Since a fluid is used, the dust is filtered off in the laboratory, carefully dried and weighed. The amount that goes into solution is also determined. The insoluble portion causes the main soiling effects.

Composition and appearance of dust.—Table I gives the composition and appearance of typical dust samples. Size determination is made with the aid of a 325 mesh screen through which the suspensions of dust from the impingers are poured. The most objectionable type of dust is apparently that found in flue gas from the plant burning petroleum coke in the powdered form, because it is high in carbon and present in large amounts. The dust from the oil burner below 40 microns in diameter has a higher combustile content than the dust above 40 microns in diameter, showing that lamp-

black is present. The solid discharge from the pulverized coal burning plant is 85.2 per cent ash and is present in large amounts, requiring the use of a dust collector in the stack. Chain grate and underfed stokers give dust containing nearly 70 per cent ash, and there are often clear fused particles of ash of from 80 to 150 microns in diameter visible under the microscope. Hand fired and spreader or overfeed stokers give dust containing appreciable amounts of combustible material. The particles of grit are often nicely rounded off and contain many surface craters. The dust from the pulverized coal burning plant was light gray in color and was not fused. Figures on loading apply to the portion of dust insoluble in the sulphurous acid collecting fluid. Thus in many cases the appearance of the particles may indicate the type of fuel burning plant responsible for discharging them into the atmosphere.

pH determinations on dust and ash sludge.—As an aid in classification of gas carbon powders and interpretation of their properties, Dr. W. B. Wiegand[3] has obtained the pH values of carbon dust sludges. He found that "Peerless" ink carbon, which is readily dispersed in drying oil, has a pH for its sludge of 2.6. Deactivated rubber carbon, which disperses readily in latex, has a pH of 10.6 for its sludge. There are many types which fall between these limits.

pH determinations were made on sludge of particulate carbonaceous materials and ash prepared by boiling 0.28 gram of material for fifteen minutes with 10cc of distilled water in a covered 100cc Pyrex beaker. The clear liquid is poured off and the cooled sludge is placed in a 5cc beaker into which the glass and calomel electrodes of a vacuum tube potentiometer amplifier dip. The potential developed is balanced and the pH value read off directly on the dial of the instrument. A type of pH instrument sponsored by Dr. P. H. Klopsteg of the Central Scientific Co. was used in this work.

Table II gives the pH values obtained for dust and ash from a number of plants investigated. The impinger dust is acid in every case. SO_2 is absorbed in the impinger liquid and affects the dust. This is evident because the pH of sludge of impinger dust ash is in every case less alkaline than the ash of the fuel from which it is formed. However, when the fuel ash is treated with 0.1 N. HCL for an hour, the residue filtered, washed and ignited, a new pH test on sludge reveals a value, which in every case is close to that for the impinger dust ash. This is shown for tests No. 12, 14 and 19. Ash of dust collected above the breeching in a manner which does not affect it chemically yields a pH for the sludge, which is similar to that for coal ash. This is shown for Tests No. 18 and 20. A difference in pH of sludge for ash of fuels from different coal mines is evident. For example the pH for ash of coal from Ziegler and Orient (No. 6 vein) in Franklin County, Illinois is 11.7, while that for ash of coal from Eastern Kentucky is 7.6. Pocahontas (W. Va.) coal ash sludge yields a pH value of 9.4. The pH of coal ash sludge depends upon the calcium, sodium and potassium present, and may also be influenced by other factors.

A test on pH of sludge of dust and its ash collected by a complainant living near a laundry in Lake View, a high grade residential section of Chicago, was made with the following results:

	pH
Combustion chamber dust of laundry	11.3
Combustion chamber dust ash	11.8
Cinders on porch of complainant	7.5
Ash of cinders on porch of complainant	11.1

There appears to be evidence linking the dust on the porch with the furnace in the laundry. Each particle has the appearance of those discharged from a spreader stoker type plant. The laundry uses a spreader type stoker.

Based upon the evidence presented here, it appears likely that pH determinations on sludge will be a valuable aid in "fingerprinting" sources of air pollution in Chicago through identification of the type of coal used.

Summary

This paper has been presented to record the application of the pH vacuum tube potentiometer amplifier in the measurement of a physico-chemical property of particulate carbonaceous material and coal ash. A number of such analyses have been recorded. pH measurements on ash sludge of coals from various districts have been made and it

has been shown that the values fall in the range 7.3 to 11.8 pH units. Differences in size and shape of dust and fly ash from various types of fuel burning equipment, when viewed under the microscope have been observed.

REFERENCES

1. Schnurer, J. Indust. Hyg. Toxicol. 19, 126, (1937).
2. Power, 84, 216, (April, 1940).
3. Wiegand, Industrial and Engineering Chemistry, 29, 953 (1937). Columbian Colloidal Carbons, p. 54, New York, (1938).

TABLE I.—COMPOSITION AND APPEARANCE OF DUST FROM FUEL BURNING PLANTS

Test No. Run No.	Source	Type Fuel Burner and Fuel	Size Dust Microns	% By Wt.	% Combustible	% Ash	Remarks on Appearance of Dust
19. R-2	Office Bldg.	Hand Fired. E. Ky.	+40	56.3	50.2	49.8	Many Rounded, Black, Pitted Coke Particles
			—40	43.7	49.0	51.0	
15. R-4	Ice Cream Mfg. Co.	Oil Burner. No. 5 Oil	+40	51.6	42.2	57.8	Shiny Black Irregular Lumps
			—40	48.4	63.6	36.4	
16. R-5	Soya Bean Products Co.	Spreader Stoker. S. W. Ind.	+40	76.6	40.2	59.8	Pitted Coke Particles No Ash Visible
			—40	23.4	32.4	67.6	
17. R-1	Meat Packing Co.	Pulverized Petroleum Coke	+40	75.0	98.1	1.9	Shiny Particles of Irregular Form
			—40	25.0	93.8	6.2	
10. R-1	Laundry	Underfeed Stoker. E. Ky.			30.1	69.9	Part of Ash Fused into Clear Spheres
14. R-4	Container Mfg. Co.	Chain Grate. N. W. Ill.			31.2	68.8	Part of Ash Fused into Colored Spheres
20. R-2A	Can Mfg. Co.	Pulverized Coal. S. Indiana			14.8	85.2	Unfused Gray Powder

TABLE II.—pH VALUES FOR SLUDGE OF DUST AND ASH

Test No. Run No.	Source	Type of Fuel Burner	Source of Fuel	pH Value of Sludge					
				Impinger Dust	Impinger Dust Ash	Fuel Ash	Fuel Ash Treated With O.In.HCL	Dust From Collector	Ash of Dust From Collector
9. R-4	Laundry	S	Western Kentucky	3.8	7.5	8.9			
11. R-3	Paint Mfg. Co.	S	Staunton, Illinois	3.6	7.1	9.5			
12. R-2	Laundry	S	Ziegler & Orient, Illinois	2.9	7.5	11.7	7.5		
14. R-4	Container Mfg. Co.	C	St. David, Illinois	4.8	7.2	11.6	7.3		
15. R-4	Ice Cream Mfg. Co.	O	No. 5 Oil	2.7	7.0				
16. R-2	Soya Bean Products	S	Sullivan County, Indiana	3.7	7.5	9.1			
17. R-5	Meat Packing Co.	Pulverized Coke	Pulv. Pet. Coke	4.7	9.5	11.2			
18. R-3	Laundry	S	Wilmington, Illinois	4.4	8.7	11.0		11.4 (Stack Washer)	11.3
19. R-4	Office Bldg.	Hand Fired	Eastern Kentucky	3.5	6.7	7.6	6.8		
20. R-3A	Can Mfg. Co.	Pulverized Coal	Maumee, Indiana	4.4	6.3	8.1		3.3 (Bubar Collector)	8.2