CHARACTERIZATION OF MUNICIPAL WASTE BY SCANNING ELECTRON MICROSCOPY AND OPTICAL MICROSCOPY

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ABSTRACT

The use of municipal waste in conjunction with coal gasification is becoming an increasingly attractive option for disposal of this waste. Characterization of the properties of the waste material is necessary before it can be utilized as a feedstock. There are considerable differences in the municipal waste generated by different communities and regions of the country and these differences can affect the gasification process. Scanning Electron Microscopy (SEM) with Energy Dispersive X-ray Microanalysis (EDX), using a backscattered electron detector, was used to examine the mineral content and morphology of the municipal waste. The fiber content and morphology was also characterized, using both optical microscopy and SEM.

INTRODUCTION

Disposal of municipal waste has been an environmental issue in recent times. Methods of disposing of this waste by incineration and composting have drawbacks. Composting requires space and time, while incineration is wasteful of the energy inherent in the sludge, and distasteful to the public. The continuing development of the coal gasification process allowing incorporation of the sludge as part of the feedstock in this process is an option for the disposal of this waste. Conversion of the sludge to electric power by this process rather than wasting its inherent energy value is the result. In terms of energy conservation this factor makes the process attractive.

There are several processing aspects which must be considered in utilizing municipal waste as a feedstock. Municipal waste must be partially dewatered before it is shipped to the gasification plant. The viscosity of the mixed coal/sludge slurry is important because it must be pumped into the reactor. Beyond the mixing ratio, some of the factors influencing the viscosity of the sludge will be due to the composition of the material, particularly the fiber content.[1] Wastes from different parts of the country and different communities will have different compositions. For instance, municipal waste from Passaic County, NJ is known to have a high content of kaolinite due to the concentration of paper producing plants in the region. Some municipalities produce a sludge with a higher fiber content than others. Minerals containing elements which are volatile at gasification temperatures may be found in

higher concentrations in one region as opposed to another. The nature of the mineral content of the sludge will have an effect on the slag produced and volatile elements may initiate formation of deposits.

Although bulk elemental analysis of sludge is essential to the characterization of the material, microanalysis through the use of optical and scanning electron microscopy techniques and Energy Dispersive X-ray microanalysis also has its place. Municipal waste is an extremely heterogeneous material and examination of this material by these techniques can provide insight on associations of the minerals with the organic content of the sludge and morphology of the fibers. Presented here are the results of microscopic characterizations performed on raw and treated samples of dewatered sludge from Los Angeles County, CA, and Passaic County, NJ.[2]

EXPERIMENTAL

SAMPLE PREPARATION

For the SEM analysis, a small amount of each sample was mounted and carbon coated using an evaporative coater to produce a conductive surface. In addition, several of the LA County samples were sputter coated with gold in order to obtain improved imaging results for documentation. The optical microscopy was performed on larger portions of the sludge.

OPTICAL MICROSCOPE

A Nikon SMZ-10 stereoscopic optical microscope was used to take color photomicrographs of the raw and treated LA County, CA municipal waste.

SCANNING ELECTRON MICROSCOPE

The instrumentation used for this study was an AMRAY 1645 SEM equipped with a lanthanum hexaboride (LaB6) electron emitter source and imaging detectors for secondary and backscattered electrons. A Tracor Northern TN-5500 Energy Dispersive X-ray microanalysis system (LSI 11/73 CPU with 3 MByte working memory and 30 MByte mass storage capacity) with a lithium-drifted silicon detector was used for semiquantitative analysis of elements with an atomic number greater than 10 and less than 92. Elemental spectral analysis was performed using standardless software routines with ZAF correction factors. The SEM conditions for analysis were 20KV acceleration voltage, 100 micron emission, 200 micron final aperture, spot size 4, working distance 24 millimeters, 0 degrees tilt, and a calculated take-off angle of 28.6 degrees. In addition to elemental analysis and photomicrography, X-ray mapping and digital image acquisition were performed on the LA County samples.

RESULTS

Optical microscopy was used to get an overview of the morphological characteristics of the municipal waste. As the figures show, the raw sludge contained a large amount of fibrous material. In addition, sprouting seeds and plastic bandage materials were found. The treated sludge materials looked darker and more granular, with little fibrous material present.

SEM/EDX microanalysis was used to verify these results and to characterize the mineral content of the waste material. It is important to understand that only a small portion of sludge was examined by microanalysis and therefore the elemental analysis is not representative of the bulk of the municipal waste.

Morphological study by both methods indicated that many of the untreated sludge particles were held together by fibrous material, mostly hair and cellulosic plant fibers. In the LA County sludge, the hair was usually long and curled around the organic material while the plant fibers which were present were thicker and often served as a base on which the organic material could anchor. The Passaic sludge was matted together, with short fibers holding the organic material together in a matrix.

Seen in the untreated LA County sludge, along with the discrete woody cellulosic materials, fibers, and mineral particles, were many particles of organic material. These had inclusions of smaller particulate mineral matter, which were often silicates. Also included within the organic matrix were fibers, woody material and even plastics or spongy material. Other inorganic mineral matter found within the matrix of these samples contained iron, barium, aluminum, zinc, magnesium, phosphorus, calcium, sulfur, potassium, and titanium. In addition to these elements, a Houston municipal waste which was characterized contained cadmium, nickel, and lead. The treated LA sludge samples were devoid of the fibrous and cellulosic material. Mineral inclusions were still present within the matrix of the organic material.

The backscattered electron detector was used to locate particles containing inorganic elements and to obtain photomicrographs when charging problems prevented good imaging by secondary electrons. X-ray mapping was useful in locating associations between elements on a broader scale. Figures 1 and 2 show the labeling of the analyzed points of solid sludge particles. The tables beneath these figures give the EDX microanalysis of the marked points. The other figures present morphological information about the different municipal wastes.

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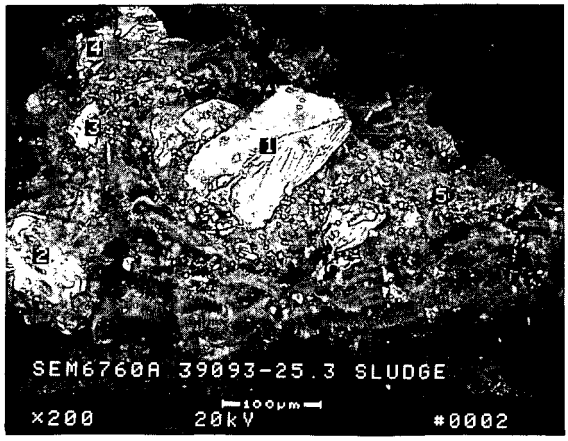

Fig.1 Los Angeles Raw Sludge (200X): A particle of sludge composed of both mineral matter and organic matter.

Analysis Table (normalized results):

ELEMENTAL ANALYSIS (WEIGHT % OF MINERAL MATTER)

POINT	Mg-K	Al-K	Si-K	P-K	S-K	Cl-K	K-K	Ca-K	Ti-K	Fe-K	Cu-K	Ni-K	Zn-K
1	--	1	94	1	1	--	-	--	--	--	3	--	--
2	1	6	3	1	1	--	7	2	3	64	9	1	2
3	1	4	1	-	1	--	-	14	1	73	5	--	-
4	5	17	2	-	1	3	-	--	-	24	41	2	4
5	2	10	19	15	13	3	1	18	2	10	5	1	1

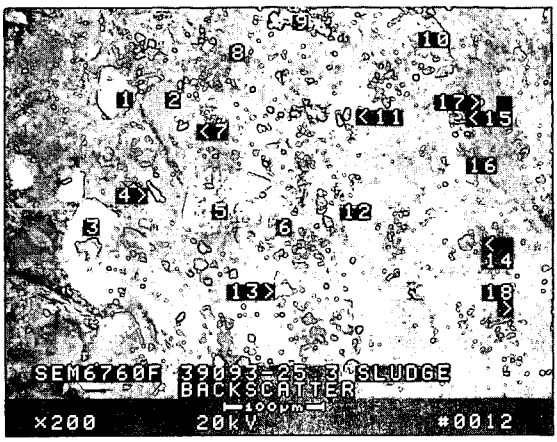

Fig.2 LA County Raw Sludge (200X): Portion of a sludge particle showing its heterogeneous nature.

Analysis Table (normalized results):

ELEMENTAL ANALYSIS (WEIGHT % OF MINERAL MATTER)

POINT	Mg-K	Al-K	Si-K	P-K	S-K	Cl-K	K-K	Ca-K	Ba-K	Ti-K	Fe-K	Cu-K	Zn-K
1	--	--	96	1	-	--	-	--	--	--	1	1	--
2	--	2	2	2	78	2	-	3	--	--	4	5	1
3	--	1	92	1	-	--	-	--	--	--	1	4	--
4	--	5	3	1	2	1	1	24	--	1	51	9	2
5	--	1	96	-	-	--	-	--	--	--	--	2	--
6	2	8	14	17	12	1	1	16	--	2	23	3	1
7	1	2	4	5	24	1	-	3	50	1	8	2	-
8	3	8	10	9	24	3	1	16	--	-	14	10	1
9	2	5	2	1	1	-	-	1	--	4	84	1	-
10	1	1	1	1	-	-	-	95	--	--	1	1	-
11	--	25	56	1	1	1	-	14	--	--	1	1	-
12	2	10	15	6	19	4	3	18	--	--	11	10	1
13	--	1	92	2	1	-	-	--	--	--	1	2	-
14	12	19	30	-	1	-	-	1	--	--	35	1	-
15	--	4	17	7	11	1	6	23	--	3	14	9	5
16	--	--	96	1	-	-	-	--	--	--	1	1	-
17	20	6	47	4	7	1	1	4	--	--	6	3	1
18	2	4	5	9	12	29	1	18	--	6	11	3	-

Fig.3 Los Angeles County Raw Sludge (6X) Optical Photomicrograph: The fibrous material holding this piece together is visible, along with some particles of inorganic material.

Fig.4 Los Angeles County Raw Sludge (18X) Optical Photomicrograph: A sprouting seed found in this municipal waste.

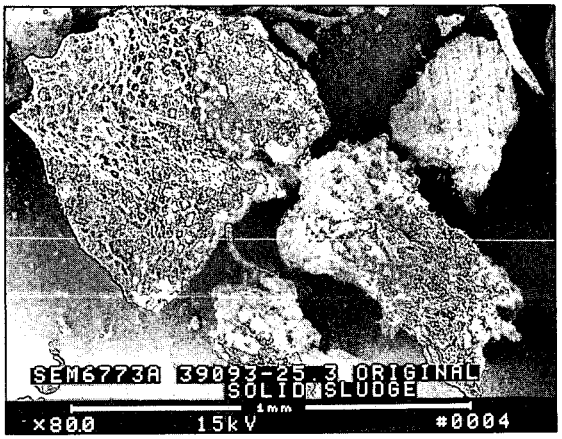

Fig.5
Raw LA County Sludge (80X): The honeycombed particle was aluminum silicate, the upper right corrugated particle was cellulosic, and two lower ones were organic matter with mineral inclusions.

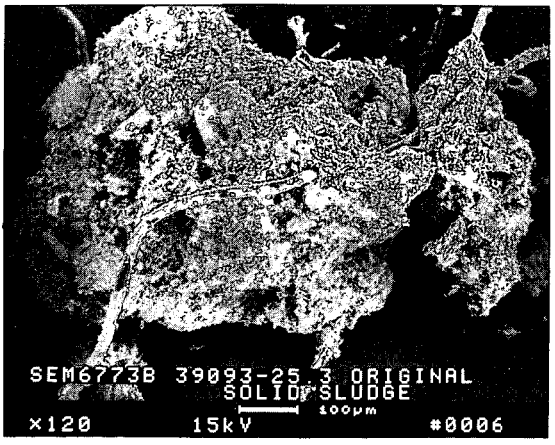

Fig.6 Raw LA County Sludge (120X): Organic particle with fibers and mineral particles included in the matrix.

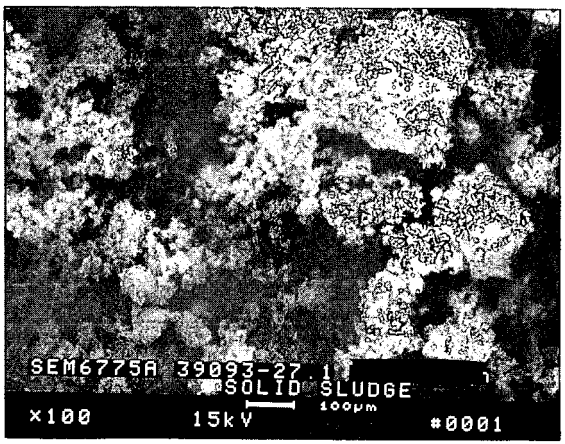

Fig.7 LA County Sludge after treatment process (100X): Fibers have disappeared and material is more homogeneous.

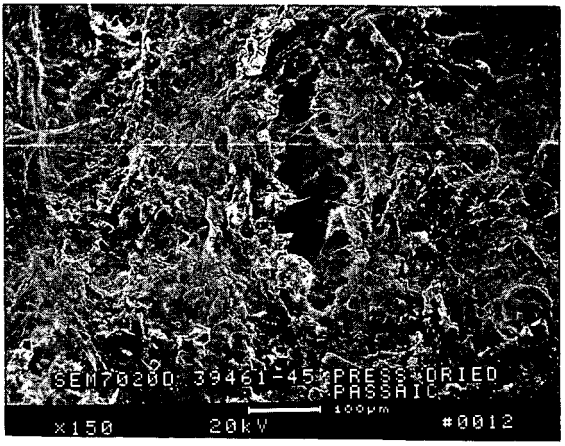

Fig. 8 Passaic Valley, NJ Sludge (150X): Fibrous sludge with mat-like morphology.