

CHARACTERIZATION OF INDORE FAN ACCUMULATED PARTICLE MATTER

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Science Degree in Chemistry

by

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of P.Thenmozhi(380300018) and R.Nandhini (38030008) who carried out the project entitled “**CHARACTERIZATION OF INDORE FAN ACCUMLATED PARTICLE MATTER**” under my supervision from December 2020 to April 2021.

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DECLARATION

We **P.THENMOZHI** and **R.NANDHINI** hereby declare that the Project Report entitled “ **CHARACTERIZATION OF INDORE FAN ACCUMLATED PARTICLE MATTER**” done by us under the guidance of **Dr. K.CHENNAKESAVULU Ph.D.**, Associate Professor Department of Chemistry, Sathyabama Institute of Science and Technology is submitted in partial fulfilment of the requirements for the award of Bachelor of Science degree in Chemistry.

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ABSTRACT

The main objective of this study was to characterize the organic constituents of concentrated PM collected on domestic and residential areas in Velacherry, Chennai. The PM samples were collected during a cold and warm period. The collected PM slurries were analyzed for their content of organic species, CHNS, TGA, BET surface area, SEM and FTIR measurements. The chemical composition of PM slurries was determined by CHNS analysis. The present study confirm the presence of halo substituted aromatic compounds, metal or metal oxides and fabric fiber or hair content in the PM.

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CHAPTER 1

INTRODUCTION

Our understanding of the relationship between human health and the indoor environment continues to evolve . health and indoor environments has tended to concentrate on discrete pollutant sources and exposures and on specific disease processes recently efforts have been made to characterize more fully the complex interactions between the health of occupants and the interior spaces they inhabit . through air inhalation dust ingestion and dermal exposure ,the indoor environment plays an important role in controlling humans chemical exposure .indoor emissions and chemistry can also have direct impacts on the quality of outdoor air . and so , it is important to have a strong fundamental knowledge of the chemical processes that occurs in indoor environment .it is important to improve our understanding of exposure to particulate matter in residences because of associated health risks .Particular matter (PM) has well-known negative health effects on humans.

PM exposure occurs mainly indoors because people spend most of their time inside buildings, especially in their homes. This study aimed at investigating the impact of the principal outdoor factors,house characteristics and indoor activities on sizefractioned PM concentrations in a real exposure scenario consisting of 60 living rooms in the province of Iodi(River po valley, Northern Italy), characterized by high pollution levels. Nearby road traffic played pivotal role for all the studied fractions, with heavy duty vehicles affecting the coarser fractions especially when building density was lower. PM 2.5-10 arose also from indoor determinants linked to cleaning activities and house volume.

The airborne concentrations of soluble ions in fine particles and coarse particles have been measured indoors and outdoors at telephone offices in Wichita, Kansas and Lubbock, Texas, These concentrations are compared with the mean annual indoor surface accumulations of these ions on Zinc and aluminum structural surfaces. On average, the major soluble ions contained in fine airborne particles are ammonium, sulfate, and nitrate, while those contained in coarse particulates are calcium and nitrate. The release of ultra-fine particulates from equipment of daily use is currently a topic of high public concern. The

present study reports on the measurement of 12 household appliances such as toasters, grills, and hair dryers in an emission test chamber regarding the release of particulates between 5.6 and 560nm. The devices were new at the time experiments started and had never been used for their original purpose. For instance, toasters and sandwich-makers were tested without the presence of food or residues from prior usage. During the experiment the devices released aerosols with count mean diameters mainly below 100nm. Within the operating phase high quantities of 10nm particles are released which form larger particles are released which form larger particles by agglomeration.

CHAPTER 2

LITERATURE SURVEY

The origin of the particles can be attributed to the heated surfaces but cleaning these surfaces only had a minor influence. This chapter addresses several chemical pollutants with respect to their sources, concentrations, and indoor-outdoor relationship. In addition, with the aim of characterizing the general quality of the indoor environment, it considers temperature, humidity, unwanted sound, and electromagnetic radiation, such as the radiofrequency, infrared, visible, ultraviolet, and X-ray portions of the spectrum. In the case of some pollutants, information on health effects is scanty, at best. To the extent possible, the health effects of such pollutants are discussed here. Detailed discussions of the health effects of other pollutants. It is important to improve our understanding of exposure to particulate matter (PM) in residence because of associated health risks.

The HOME Chem campaign was conducted to investigate indoor chemistry in a manufactured test house during prescribed everyday activities, such as cooking, cleaning, and opening doors and windows. This paper focuses on measured size distributions of PM(0.00.-20 μ m), along with estimated exposures and respiratory tract deposition. Number concentrations were highest for sub-10 nm particles during cooking using a propane-fueled stovetop. During some cooking activities, calculated PM_{2.5} mass. The modeled PM respiratory deposition for an adult residing in the test house kitchen for 12h varied from 7g on a day with no indoor activities. Our understanding of the relationship between human health and the indoor environment continues to evolve. Previous research on health and indoor environments has tended to concentrate on discrete pollutant sources and exposures and on specific disease processes. Recently, efforts have been made to characterize more fully the complex interactions between the health of occupants and the interior spaces they inhabit. In this article we review recent advances in source characterization, health effects. Through air inhalation, dust ingestion and dermal exposure, the indoor environment plays an important role in controlling human chemical exposure. Indoor emissions and chemistry can also have direct impacts on the quality of outdoor air. And so, it is

important to have a strong fundamental knowledge of the chemical processes that occur in indoor environment. This review article summarizes our haddresses primarily the new advances that have occurred in the past decade or so and upon developments in our understanding of multiphase partitioning and reactions. Being a complex mixture of chemicals directly released from sources or formed as a product from gas to particle conversion through chemical reactions, fine particles (PM_{2.5}, PM₁) represent a major research challenge in atmospheric science. Their health significance is consistently demonstrated by numerous epidemiological studies since they have a higher probability than the larger particles to induce adverse health effects up to premature deaths. Among the various harmful PM components, Polycyclic Aromatic Hydrocarbons (PAHs) are considered to be the most dangerous since they contribute to alarge extent or even enhance the toxic potency of the airborne particles **(Pateraki et al., 2020)**. Several studies have linked the inhalation of fine airborne particulate matter (PM_{2.5}, PM with aerodynamic diameter < 2.5 µm) to a wide range of adverse health outcomes, including respiratory, cardiovascular, neurodegenerative, metabolic, and cancer diseases. These adverse effects prompted the need for in vitro and in vivo toxicological investigations of the health impacts of exposure to PM_{2.5}, using aerosols that are representative of ambient PM (**Solimanian et al 2021**).

CHAPTER 3

AIM AND SCOPE

Particle Matter, which is accumulated on Fan in Velacherry area were collected and characterized for the following.

- Thermal stability by TGA
- The Elemental composition by CHNS elemental analysis
- Chemical entities present in the PM by FTIR
- Morphology by SEM
- Surface area of the PM by BET measurements

CHAPTER 4

MATERIALS AND METHODS

4.1 FTIR

FTIR method is used to obtain the infrared spectrum of transmission or absorption of a fuel sample. FTIR identifies the presence of organic and inorganic compounds in the sample. Depending on the infrared absorption frequency range $600\text{--}4000\text{ cm}^{-1}$, the specific molecular groups prevailing in the sample will be determined through spectrum data in the automated software of spectroscopy. In this chapter, FTIR has been used as a novel approach to characterize the variability in fuel stability of various biodiesel/antioxidant samples. Fourier transform infrared spectroscopy (FTIR) is a technique which is used to obtain infrared spectrum of absorption, emission, and photoconductivity of solid, liquid, and gas. It is used to detect different functional groups in PHB. FTIR spectrum is recorded between 4000 and 400 cm^{-1} . For FTIR analysis, the polymer was dissolved in chloroform and layered on a NaCl crystal and after evaporation of chloroform, the polymer film was subjected to FTIR. The spectrum of PHB shows peaks at 1724 cm^{-1} and 1279 cm^{-1} , which corresponds to specific rotations around carbon atoms. The peak at 1724 cm^{-1} corresponds to C–O stretch of the ester group present in the molecular chain of highly ordered structure and the adsorption band at 1279 cm^{-1} corresponds to ester bonding. The FTIR is the technique used to obtain an infrared spectrum of absorption or emission of a solid, liquid and gas. FTIR can be used to collect high spectral resolution data over a wide range, usually between 5000 and 400 cm^{-1} for mid-IR region wavelength, and between $10,000$ and 4000 cm^{-1} for near-IR region wavelength. For a typical FTIR, the resolution is 4 cm^{-1} . A straightforward way for this absorption measurement is to shine a monochromatic light beam at a sample and measure how much of it is absorbed. Repeating corresponding test parameters can control the number of measurements for each different wavelength. In FTIR, light of many frequencies can be measured simultaneously and this process can be repeated many times. This gives FTIR an advantage, i.e., it results in a higher for a specific scanning time.

FTIR can be used for microscopy and imaging of rubber and particle interfacial modifications. For example, the physically-absorbed water can be characterized through peaks between 3800 and 3200 cm^{-1} (i.e., —OH stretching vibrations). More conveniently, when this vibration combines with the bending mode of water molecules, it generates bands from 5050 to 5350 cm^{-1} range. In PDMS-based composites, both silica [87] and titania [88] have been well studied regarding this IR absorption.

Fourier transform infrared spectroscopy (FTIR) is an effective tool in determining the surface chemical composition of rigid foams. The absorbance of a sample to an incident infrared spectrum in the range of 900 to 3600 cm^{-1} constitutes the analysis. The major bands and their significance are FTIR in the embodiment of diffuse or attenuated total reflectance FTIR can be used to determine the correlation between temperature gradients generated during the processing with gradients in chemical constitution in the foam dimensions. FTIR can also effectively highlight incomplete polymerisation when compared with a standard sample. It is clearly evident that graphene and porous graphene show a common absorption band. The bands at 2920 cm^{-1} and 2850 cm^{-1} are attributed to the —CH groups, and the band at 2360 cm^{-1} corresponds to CO_2 . Further, band at 1627 and 1390 cm^{-1} are assigned to the $\text{C}=\text{C}$ vibration and —CO stretching vibrations, respectively. In addition, to the above bands, the FTIR spectra of porous graphene shows some new low-intensity peaks. In porous graphene, the band at 3418 cm^{-1} is due to the —OH group, and the peak at 1726 cm^{-1} is attributed to the —COO group. Further, the broad band appearing at 1096 cm^{-1} is due to —C—O— group, and the peak of 915 cm^{-1} is corresponding to the —C—O—C group.

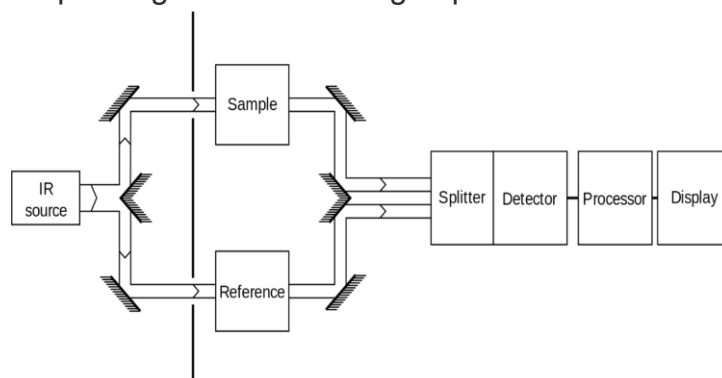


Fig.4.1.1 Block diagram of FTIR

4.2 SEM (SCANNING ELECTRON MICROSCOPE)

An electron beam to image samples with a resolution down to the nanometer scale. The electrons are emitted from a filament and collimated into a beam in the electron source. The beam is then focused on the sample surface by a set of lenses in the electron column. How does an electron lens work? And which kind of lenses exist? How are lenses combined to form an electron column? In this blog, we will answer these questions and give a general insight into the working principle of an electron column. As the name implies, electron microscopes employ an electron beam for imaging. you can see the various products that are possible as a result of the interaction between electrons and matter. All these different types of signals carry different useful information about the sample and it is the choice of the microscope's operator which signal to capture.

In SEM, two types of electrons are primarily detected:

- Backscattered electrons (BSE),
- Secondary electrons (SE),

Backscattered electrons are reflected back after elastic interactions between the beam and the sample. Secondary electrons, however, originate from the atoms of the sample: they are a result of inelastic interactions between the electron beam and the sample. BSE come from deeper regions of the sample, while SE originate from surface regions. Therefore, BSE and SE carry different types of information. BSE images show high sensitivity to differences in atomic number: the higher the atomic number, the brighter the material appears in the image. SE imaging can provide more detailed surface information. Electrons are emitted from the filament of an electron source and subsequently collimated into a beam.

SEM Instrument

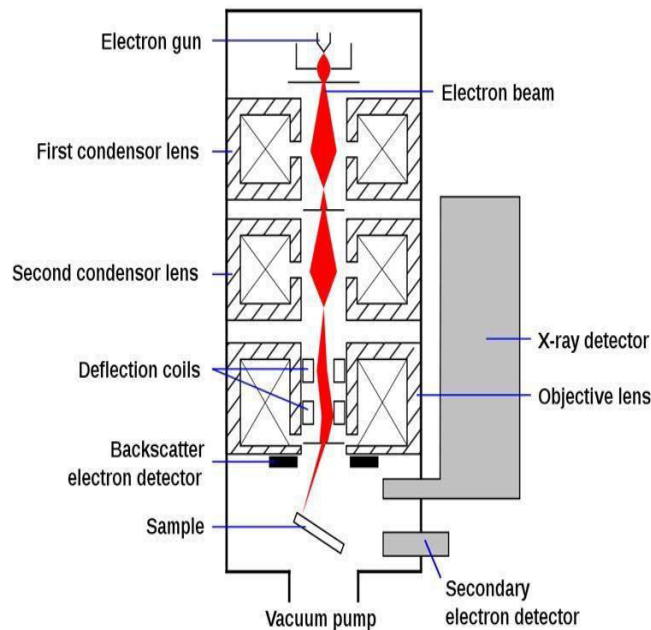


Fig.4.2.1 SEM instrumentation

The electron beam travels through the electron column, which consists of a set of lenses that focus the beam onto the sample surface. Electron microscope lenses can be electrostatic or magnetic, depending on whether they use an electrostatic field or a magnetic field to focus the electron beam. To better understand how these lenses work, let's take a step back and look at how electrons can be deflected in an electrostatic field. Electrons are negatively charged particles and travel through the electron column at high energy and high speed. One way to deflect these particles is to let them travel through an electric field generated by two plates at potential $+U$ and $-U$. Under the influence of the electric field, the electron is deflected at an angle that depends on the electron energy, the electric field applied in between the plates, and the length of the plates.

The faster, or the more energetic the electron, the smaller the deflection angle. The higher the electric field and the longer the plates, the bigger the deflection angle. A device consisting of two plates at different potential is called a deflector.

To get an electrostatic lens, one could think of mirroring the effect of a deflector, such that the outer electrons traveling off the optical axis can be focused on the same point.

Starting from the fact that electric fields can only start and end on electron charges, how can we get a lens effect. The answer to this question lies in the fact that whenever there is a lens effect, the energy of the beam changes, meaning that the electrons either accelerate or decelerate. This can be done simply by having an aperture on different potential around the beam. Electrostatic lenses consist of metallic plates connected to high voltage with an aperture that the electron beam travels through. Single-aperture lenses consist of a single metallic plate at high voltage and can often be found in electron sources.

4.3 ELEMENTAL ANALYSIS (CHNS)

The purpose of elemental analysis is to determine the quantity of a particular element within a molecule or material. Elemental analysis can be subdivided in two ways:

- Qualitative: determining what elements are present or the presence of a particular element.
- Quantitative: determining how much of a particular or each element is present.

In either case elemental analysis is independent of structure unit or functional group, i.e., the determination of carbon content in toluene ($\text{C}_6\text{H}_5\text{CH}_3$) does not differentiate between the aromatic sp^2sp^2 carbon atoms and the methyl sp^3sp^3 carbon.

Elemental analysis can be performed on a solid, liquid, or gas. However, depending on the technique employed the sample may have to be pre-reacted, e.g., by combustion or acid digestion. The amounts required for elemental analysis range from a few gram (g) to a few milligram (mg) or less.

Elemental analysis can also be subdivided into general categories related to the approach involved in determining quantities.

- Classical analysis relies on stoichiometry through a chemical reaction or by comparison with known reference sample.
- Modern methods rely on nuclear structure or size (mass) of a particular element and are generally limited to solid samples.

Many classical methods they can be further classified into the following categories:

- Gravimetric in which a sample is separated from solution as a solid as a precipitate and weighed. This is generally used for alloys, ceramics, and minerals.
- Volumetric is the most frequently employed involves determination of the volume of a substance that combines with another substance in known proportions. This is also called titrimetric analysis and is frequently employed using a visual end point or potentiometric measurement.
- Colorimetric (spectroscopic) analysis requires the addition of an organic complex agent. This is commonly used in medical laboratories as well as in the analysis of industrial wastewater treatment.

The biggest limitation in classical methods is most often due to sample manipulation rather than equipment error, i.e., operator error in weighing a sample or observing an end point. In contrast, the errors in modern analytical methods are almost entirely computer sourced and inherent in the software that analyzes and fits the data. that carbon content was greater than 90% and the sum of carbon (C), and hydrogen (H₂), was 99.5 t%, whereas no other element is present in as high a percentage that would affect the further surface engineering or conjugation process. Upon purification of the pristine MWCNTs the atomic percentage of H₂ increased up to 5.3%, which indicates the generation of some oxygen-containing groups along with hydrogen. The elemental analysis of the different functionalized MWCNTs indicates the proportionate change in the atomic percentage of the various atoms (C, H, and N), which further confirms the conjugation the classical method to obtain information about the elemental composition of an unknown substance [70,71]. A known amount of unknown substance is converted to simple, known compounds containing only the element

to be quantified. For instance carbon and hydrogen are determined in organic compounds by conversion through combustion to carbon dioxide and water followed by quantitative analysis of the latter compounds. Nitrogen is converted to nitrogen gas. An exact match between the theoretical composition, calculated assuming polymerisation, and the analytical results indicates that the polymerisation has incorporated all stoichiometrically in high yield [72]. Reactions with the polymer, for instance removal of template, are most easily detected when the removed or added species contain an element such as nitrogen, halogen, sulphur. For instance in the imprinting of phosphorus for ester hydrolysis the amount of phosphorus in the polymer was determined by trace elemental analysis prior to (0.081%) and after (0.0015%) splitting, giving a splitting yield of about 98% [73].

4.4 SURFACE AREA (BET)

The determination of specific surface areas represents a major task regarding the characterization of porous and finely dispersed solids. Gas adsorption is the appropriate method to solve this task. If a gas gets in contact with a solid material, a part of the dosed gas molecules is being adsorbed. The amount of gas depends on the gas pressure, the temperature, the kind of the gas and the size of the surface area. After choosing the measuring gas and temperature, the specific surface area of a solid material can be reliably and comparably calculated. From the adsorption isotherm. Due to practical reasons the adsorption of nitrogen at a temperature of 77 K (liquid nitrogen) has been established as the method for the determination of specific surface areas.

BET method actually means the analysis of isotherm data by a method developed by Brunauer, Emmett and Teller. By means of the BET equation the amount of adsorbed gas, which builds up one monolayer on the surface, can be calculated from the measured isotherm. The amount of molecules in this monolayer multiplied by the required space of one molecule gives the BET surface area. Besides the adsorption of nitrogen at 77 K, krypton adsorption at 77 K is recommended for the determination of very small surface area.

- The choice of the measuring instrument depends on: Scope of the task (only for BET) surface area or also the pore volume and pore size distribution)

- The range of the surface area of the materials (the determination of very small surface areas by krypton adsorption requires a special measuring technique (**Chennakesavulu et al. 2010**)).
- The desired throughput (1,2,3 or 4 station instrument)



Fig. 4.4.1 BET INSTRUMENT

CHAPTER 5

RESULTS AND DISCUSSION

5.1 ELEMENTAL ANALYSIS

In order to see the elemental composition of the PM, the samples were subjected to elemental analysis and the results show that the PM has C, H and N and S elements.

Table 5.1.1: Elemental analysis of PM

TruSpec Micro Elemental analysis				
Sample Weight	% C	% H	% N	% S
2.0440 mg	24.841	3.6238	9.1961	0.59721
2.0850 mg	26.622	3.3405	10.3310	0.97430

5.2 TGA ANALYSIS

Thermo Gravimetric Analysis of Fan accumulated material was done in static air atmosphere. The result was shown in Fig. It is observed that the Fan accumulated material was thermally highly stable. It reveals that the 50% of the material is stable even above 900 °C.

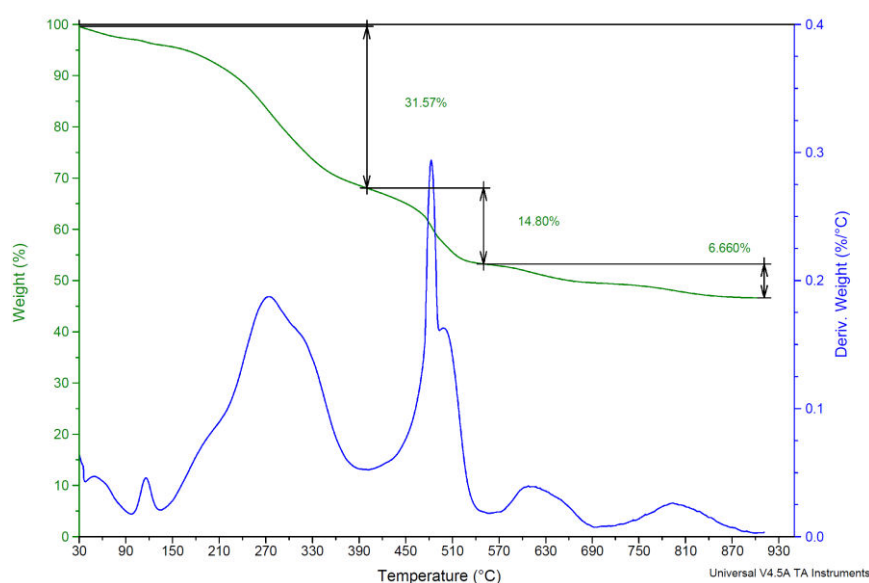


Fig.5.2.1 TGA of Particle Matter collected at Velacherry Area in Chennai

5.3 MORPHOLOGY OF COLLECTED PM

From Fig. 5.3.1 and 5.3.2 reveals that PM contains textile or fabric cellulose material and FTIR suggests that the halogen-containing organic compounds. The brightness of the images also indicates the presence of metal or metal oxide materials in the PM.



Fig.5.3.1 The photographic image of PM collected in Velachery, Chennai

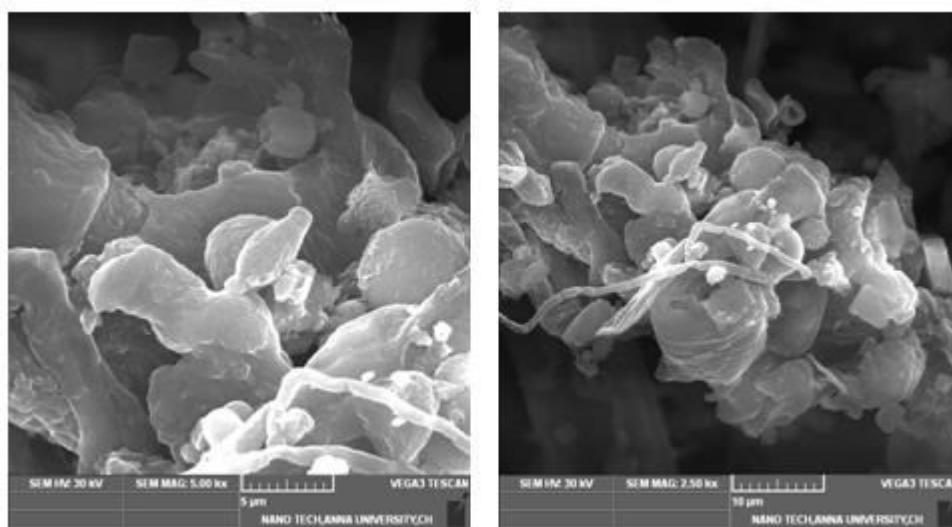


Fig. 5.3.2 SEM images of PM

The SEM result reveals that the presence of micro scale material, i.e. hair or fabric fiber matter in the PM. The Thermal stability and the SEM results suggest that the presence of metal or metal oxide material in PM.

5.4 ADSORPTION ISOTHERM OF PM

The adsorption and desorption isotherm was shown in Fig. 5.4.1. The BET surface area was measured to 1.6 m²/gm. Though the expected the surface area of PM is high, the results are contradictory to our expectation. This might be due to presence of metal or metal oxide in the PM.

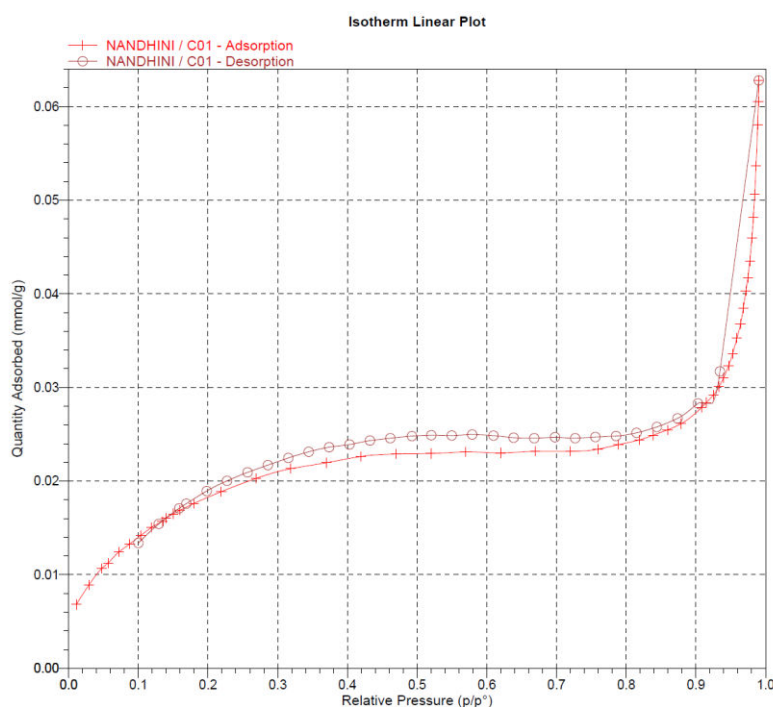


Fig. 5.4.1 Nitrogen Adsorption isotherm of PM

5.5 FTIR ANALYSIS

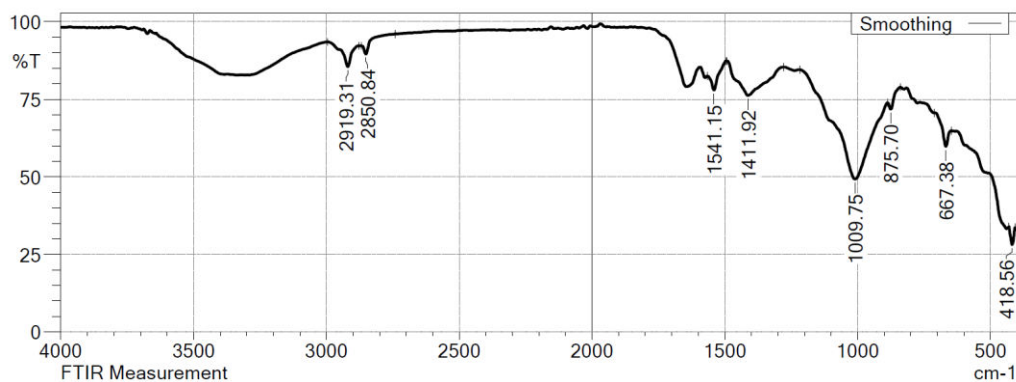


Fig. 5.5.1 FTIR spectrum of PM

The peaks at 2919 cm^{-1} and 2850 cm^{-1} clearly indicates the presence of methyl group and aromatic groups in the PM. The peaks at 1009 cm^{-1} to 418 cm^{-1} clearly indicates the presence of halogen in the PM.

CHAPTER 6

SUMMARY AND CONCLUSIONS

- Elemental analysis reveals that the composition of PM is C = 25%, H = 3.5% ; N = 9.5%; S = 0.75%.
- FTIR clearly suggest the the methyl substituted aromatic hydrocarbons
- Surface area the PM was reported to be 1.6 m²/gm, this could be considered as indirect evidence for the presence of metal or metal oxide materials
- SEM results suggest that the presence of hair or textile fiber in PM and the brightness of the image indicates the presence of metal or metal oxide in the PM
- TGA results suggest the the 50% PM was highly stable even at 900 °C.

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