A Project Report on

"POWDER CHARACTERIZATION AND ELECTRO STATIC HAZARDS IN INDUSTRIAL PROCESSES"

Dissertation submitted in partial fulfilment of the requirements for the award of the degree

of

BACHELOR OF TECHNOLOGY

In

CHEMICAL ENGINEERING

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CERTIFICATE

This is to certify that the project entitled "POWDER CHARACTERIZATION AND ELECTRO STATIC HAZARDS IN INDUSTRIAL PROCESS" is a bonafide work of **A UDAY KIRAN RAJU (**20001A0832**), MALYAVANTHAM NARESH (**20001A0862**), GOLLA NAGA PRAVALLIKA YADAV (**20001A0863**), KILLADA SHYAM KUMAR (**20001A0843**), KURUBA BHARGAVI(**20001A0801**)** submitted to the department of chemical engineering in partial fulfilment of the requirements for the award of the degree of **BACHELOR OF TECHNOLOGY** from Jawaharlal Nehru Technological University College of Engineering (Autonomous), Anantapuramu, Andhra Pradesh.

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We, A UDAY KIRAN RAJU, M NARESH, G NAGA PRAVALLIKA YADAV, K . SHYAM KUMAR, K. BHARGAVI, certify that the work entitled "POWDER CHARACTERIZATION AND ELECTRO STATIC HAZARDS IN INDUSTRIAL PROCESSES" embodied in this dissertation is carried out under the supervision of Dr. P. Uma Maheshwari Assistant Professor (c) Department of Chemical Engineering JNTUA College of Engineering Anantapuramu. The project report's findings have not been submitted to any other University or Institute for the award of any Degree. we further declare that , we have not intentionally replicated any other person's work, paragraphs, text, Data, findings etc, reported in journals, books, magazines, reports, dissertations, thesis etc or available on the internet and have not incorporated them in my thesis or cited them on my own.

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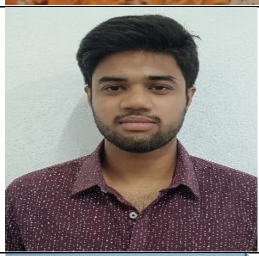
KILLADA SHYAM KUMAR(20001A0843)		
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Gratitude takes three forms "a feeling from the heart an expression in words and giving in return".

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ABSTRACT

This project investigated the physical and chemical properties of essential powders used in reactor-based processes for powder production at Everest Organics Pvt. Ltd. The primary goal was to understand how static electricity arises during filling and discharging of these materials into reactors, focusing on critical powder characteristics. The project identified key physical and chemical properties, including Density, Porosity, Flowability, Thermal Conductivity, Electrical Conductivity, and Static Electricity. Further analysis explored powder design characterization, quality control, and process optimization. By examining industry accidents and incidents, the project aimed to develop a clear understanding of static electricity dissipation and effective powder handling procedures. An innovative approach utilized am-probe instrument instead of a traditional static electricity analyzer to measure static electricity of various compounds. All unit operations and unit processes were considered for this study. Finally, the project tested and validated practical preventive methods for static electricity generation and implemented effective control measures.

Keywords: Static Electricity, Bulk Density, Tapped Density, Porosity, Flowability, Thermal Conductivity, Electrical Conductivity.

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NOTATIONS

gm	GRAMS
ml	MILLI LITERS
k	THERMAL CONDUCTIVITY
Q	POWER
L	LENGTH OF THE BEAKER
A	CROSS SECTIONAL AREA
ΔT	TEMPERATURE DIFFERENCES
W	WATTS
m	METER
K	KELVIN
S	SIMENS

CHAPTER-1

INTRODUCTION

1.1 INTRODUCTION ABOUT STATIC ELECTRICITY:

The possible causes of mishaps in the pharmaceutical industry includes “FISH” (Friction, Impact, Static Electricity and Heat). The project's primary motivation is "Static Electricity."

An imbalance between an object's positive and negative charges leads to static electricity. Numerous mishaps occur in industries as a result of static electricity. During production (loading and unloading) or when transferring bulk powder from one location to another, sparks are generated from the product. Static electricity is produced during this, which causes significant losses for the industry [1].

The project's primary goal is to prevent industrial mishaps brought on by static electricity.

Static Electricity: A Potential Spark Hazard

Static electricity is a significant source of electrical sparks. It arises whenever two surfaces come into contact and separate. Many static charges quickly dissipate to the ground upon formation. However, charges on insulators or ungrounded conductors can persist for a while. If the voltage (charge level) becomes high enough, a spark discharge can occur, potentially igniting flammable vapors present, appearing like small flames [1].

Understanding Static Electricity:

Static electricity refers to electrical charges trapped on the surface of an insulator or a conductor isolated from ground. It develops in three stages:

1. **Charge Separation:**
   When two dissimilar materials contact, their electrons redistribute to achieve a balanced state. This movement creates an imbalance of charges on each surface.
2. **Charge Accumulation:**
   As separation continues, one material gains electrons (becomes negatively charged) while the other loses electrons (becomes positively charged).
3. **Static Discharge:**
   When the accumulated voltage reaches a critical point, a spark discharges the built-up charge, potentially causing problems in flammable environments.

Monitoring Static Electricity:

Several instruments help monitor electrostatic fields:

1. **Static Meter:**

   This portable device, often called a field monitor as shown in figure 1.1 measures the voltage between a charged object and the induced charges in its sensor. It provides a non-contact measurement by bringing the probe close to the object (1-5 mm)

2. **Electroscope:**

   This simple tool, commonly used in classrooms, utilizes thin metal leaves that diverge when charged as shown in figure 1.2. The degree of separation indicates the presence and strength of the charge.

3. **Spark Gap Tester:**

   This method involves placing a grounded electrode near the charged object as shown in figure 1.3. The spark discharge distance reflects the voltage potential of the charge.

4. **Electrostatic Voltage Meter:**

   These direct-contact meters measure the voltage difference (charge difference) between a charged object and the ground as shown in fig 1.4. They typically consist of a sensor that detects the induced voltage and a probe that contacts the object. The measured voltage is then displayed on an analog or digital scale.

Fig 1.1 Static meter

Fig 1.2 Electroscope

Fig 1.3 Spark gap tester

Fig 1.4 Electrostatic voltage meter

Static Electricity Risks:

1. **Explosion and Fire Hazard:**

   The most significant risk arises in environments where combustible materials like dust, gas, or fumes are present. Static discharges can create sparks that ignite these materials, leading to flames or even explosions. This poses a major threat in industries such as grain mills, chemical plants, and refineries.

2. **Electronic Damage:**

   Electrostatic discharge (ESD) is a frequent culprit behind damage to sensitive electronic components. Devices like laptops, tablets, and medical equipment can malfunction, lose data, or suffer permanent damage due to ESD events.

3. **Human Discomfort and Startle Effects:**

   Those unexpected shocks from doorknobs or from touching someone with a static buildup can be unpleasant and startling, even though they're usually harmless. In some cases, these shocks could potentially lead to falls or accidents.

Sources of Static Electricity

1. **Contact and Separation:**

   The most common cause is when two materials contact and separate, leading to a re-distribution of electrons.

2. **Liquid Movement:**

   Flowing liquids (solvents, chemicals) in contact with other materials can also generate static electricity through friction. Processes like pouring, pumping, filtering, and stirring can all contribute.

3. **Powder Handling:**

   Due to the high surface area involved, static electricity is almost unavoidable during powder processing. Poorly conducting powders readily accumulate charges on themselves, processing equipment, and isolated metal components within the plant.

SPARK GENERATION IN POWDERS:

Spark discharges happen when there is close contact between two materials with different electrical potential as shown in figure 1.1. In a factory, spark discharges happen when one isolated piece of equipment, like a metal pipe, becomes charged and comes close to another object, or even an operator, that has a different charge. The difference of electrical potential between the two objects can cause an electrical spark discharge [2].

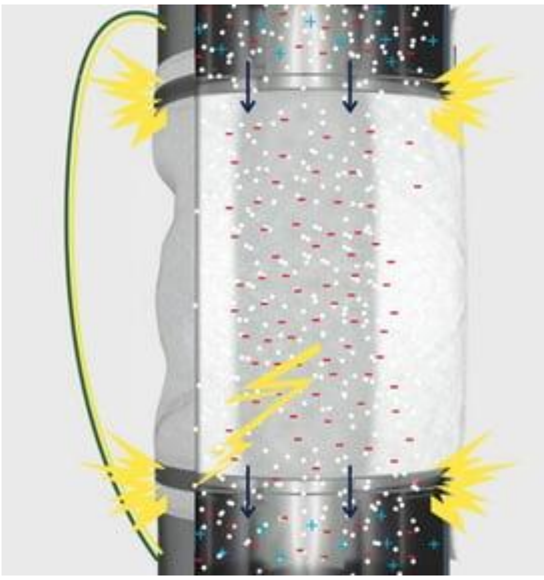

Fig 1.5 Spark generated in reactors

1.2 BASIC HAZARDS:

An electrostatic hazard exists in a powder if the bulk powder or its dust cloud is sensitive to electrostatic discharge. A powder/air mixture can react explosively once ignited by an electrostatic discharge (ESD) or other energy source igniting the bulk powder. This reaction would propagate into explosion (primary and secondary) over large areas of manufacturing operations.

Electrostatically hazardous conditions may occur if one or more of the following exist:

- Powder is reactive (in bulk or in dust cloud).
- Electrostatic charges develop.
- Electrostatic discharges occur.
- Powder ESD ignition energy less than in process ESD energy.
- Propagation of reaction to explosion or massive fire.
- High exposure of personnel and facilities to incident.

In hazards evaluation, first step is to determine whether the material is reactive in either a layer or a dust cloud suspension. If it is reactive, the next step in the hazard analysis is to determine the minimum energies required to initiate the particular dust material. If the initiation energies are extremely low (low ignition temperature or low electrostatic discharge initiation energies), the powder electrostatic charging characteristics are evaluated. From this, we can determine whether sufficient electrostatic charge energies can develop in various stages of bulk powder handling to constitute an initiation hazard. The next step is that of determining ways in which the hazard can develop in the manufacturing or process plant operations and the probabilities that these events will occur.

1.3 CHARACTERISTICS OF PHARMAPOWDERS:

The Characteristics of the Pharma powders calculated be

1. Bulk Density
2. Tap Density
3. True Density
4. Porosity
5. Flowability
6. Thermal Conductivity
7. Electrical Conductivity

Bulk density: Bulk density is the mass of bulk solid that occupies a unit volume of a bed, including the volume of all inter particle voids

Tapped density: The tapped density is an increased bulk density attained after mechanically tapping a container containing the powder sample. The tapped density is obtained by mechanically tapping a graduated measuring cylinder or vessel containing the powder sample.

True density: True density is the measure of the solid particles in a powder or granule. In this solvent is used to fill the voids in the powder bed to measure the volume taken up by the powder. True density is the density of a material at 0% porosity

Porosity: The porosity of powders is determined from the raw density (solid state volume) and the pore volume

Flowability: Powder flow, also known as flowability, is defined as the relative movement of a bulk of particles among neighboring particles or along the container wall surface.

Electrical conductivity: Electrical conductivity is a measurement of how easily a material allows electric current to flow through it.

Thermal conductivity: Thermal conductivity is defined as the ability of a material to conduct heat from its one side to the other. It is represented with thermal conductivity coefficient λ. Smaller λ indicates that the material has stronger heat insulation and preservation.

Importance of the characteristics of powder:

1. **Product Quality and Performance:**

Food and Pharmaceuticals: In food and pharmaceutical industries, consistent powder characteristics like particle size and density are essential for ensuring proper mixing, flow during processing, and ultimately, the final product's quality and effectiveness.

Cosmetics: For cosmetics, powder characteristics like size and shape influence factors like texture, application, and absorption, impacting the product's performance and user experience.

2. **Process Optimization and Efficiency:**

Handling and Storage: Knowing flowability characteristics helps design efficient storage and handling systems. Powders with poor flowability can cause blockages in hoppers or difficulty during transportation.

Machinery Design: Understanding characteristics like density and particle size is crucial for designing equipment that can properly process the powder. For example, milling machinery needs to be adjusted based on the powder's hardness and particle size.

3. **Safety Considerations:**

Combustibility: Powders with high surface area and low moisture content can be more susceptible to dust explosions. Understanding characteristics like particle size and density helps assess these risks.

Inhalation Hazards: Powders with very fine particles can pose inhalation risks. Characterization helps implement proper handling procedures and safety measures.

4. **Material Development:**

New Materials: In research and development, characterizing powders is essential for creating new materials with specific properties. By tailoring particle size and shape, scientists can influence factors like electrical conductivity or reactivity.

Material Substitution: When finding substitutes for existing materials, characterization helps ensure the new powder has the necessary properties for the intended application.

1.4 POWDER HAZARD IDENTIFICATION, RISK ASSESSMENT, RISK PREVENTION, RISK CONTROL WITH 5 'S' & ERGONOMICS:

Mostly hazards and risks involved in the industry that have been observed be Road transport vehicle unloading, Reactor, Production Block, Transportation of Solid Powders from ware house to production block, Transfer of Solid Powders from Reactor to Centrifuge and Centrifuge to Container.

Table-1.1: Road Transport Vehicle Unloading

Location/Area	**Road transport vehicle unloading**
Check list to be monitored:	1. Static electricity discharge clips 2. Temperature of vehicle 3. Condition of water sprinkler/volume of water in sump 4. Pressure of water in fire hydrant system 5. Any leakages to be detected with hand held digital meter 6. Ware house condition 7. Wind direction 8. Check cleanliness
Unit Operation	Transportation of solids
Unit Process	Not applicable, but in case of leakage, certain powders may react
Hazard identification	Fire
Risk assessment	Minimal(1-2)
Risk prevention	1. To follow check list. 2. Immediate stop of activity.
Risk control(3 Tier)	1. Sensor will trip the water sprinklers on. 2. Fire hydrant will trip on. 3. Trained persons to manage
5 \`S\` systems	1. Sort: unwanted stuff 2. Set in order: keep things in place 3. Shine: clean all the values everyday

	4. Standardize: get quality check by colleague 5. Sustain: get quality check by third party
Ergonomics	1. Provide hand gloves and other PPE 2. Provide pleasant environment 3. Provide paintings/ maintenance regularly

Table-1.2: Reactor

Location/Area	**Reactor**
Check list to be monitored:	1. Static electricity discharge clips 2. Pressure and temperature gauge to be checked 3. Valves of storage tank 4. Pressure of water in fire hydrant system 5. Any leakages to be detected with hand held digital meter 6. Ware house condition 7. Wind direction 8. Check cleanliness
Unit Operation	Heat transfer
Unit Process	Not applicable, but in case of leakage will react with fire, water, human skin, eye.
Hazard identification	Leakage of gas
Risk assessment	Medium(10-15)
Risk prevention	1. To follow check list. 2. Immediate stop of activity,with regards to bio sensor
Risk control(3 Tier)	1. Sensor will trip the water sprinklers on. 2. Fire hydrant will trip on. 3. Trained persons to arrest leakage
5 \`S\` systems	1. Sort: Remove unwanted stuff

	2. Set in order: keep things in place 3. Shine: clean all the values everyday 4. Standardize: get quality check by colleague 5. Sustain: get quality check by third party
Ergonomics	1. Provide hand gloves and other PPE 2. Provide pleasant environment 3. Provide paintings/ maintenance regularly

Table-1.3: Production Block

Location/Area	**Production Block**
Check list to be monitored:	2 Static electricity discharge clips 3 Temperature gauge and pressure at reactor inlet and outlet 4 Pressure of water in fire hydrant system 5 Condition of water sprinkler at feed point/volume of water in sump 6 Any leakages to be detected with hand held digital meter 7 Ware house condition 8 Wind direction 9 Check cleanliness
Unit Operation	Fluid flow, Heat transfer
Unit Process	Nitro reaction
Hazard identification	Leakage of gas
Risk assessment	High (16-20)
Risk prevention	1. To follow check list. 2. Immediate stop of activity, with regards to bio sensor
Risk control(3 Tier)	1. Sensor will trip the water sprinklers on. 2. Fire hydrant will trip on. 3. Trained persons to arrest leakage
5 \`S\` systems	1. Sort: Remove unwanted stuff

	2. Set in order: keep things in place 3. Shine: clean all the values everyday 4. Standardize: get quality check by colleague 5. Sustain: get quality check by third party
Ergonomics	1. Provide hand gloves and other PPE 2. Provide pleasant environment 3. Provide path to easy escape, in case of gas leakage 4. Provide paintings/ maintenance regularly

Table-1.4: Transportation Pathway

Location/Area	**Transportation Pathway**
Check list to be monitored:	1. Static electricity discharge clips 2. Close containment 3. Wind direction 4. Check cleanliness
Unit Operation	Solid material conveying
Unit Process	NA
Hazard identification	Leakage of gas
Risk assessment	High (16-20)
Risk prevention	1. To follow check list. 2. Immediate manage
Risk control(3 Tier)	1. PPE 2. Suppression/Extinguishing 3. Zoning
5 \`S\` systems	1. Sort: Remove unwanted stuff 2. Set in order: keep things in place 3. Shine: clean all the values everyday 4. Standardize: get quality check by colleague

	5. Sustain: get quality check by third party
Ergonomics	1. Provide hand gloves and other PPE 2. Provide pleasant environment 3. Provide hand rails on the top of reactor 4. Provide path to easy escape, in case of gas leakage 5. Provide paintings/ maintenance regularly

Table-1.5: Unfinished Powder Transfer

Location/Area	**Unfinished Powder Transfer**
Check list to be monitored:	1. Static electricity discharge clips 2. Close containment 3. Check cleanliness
Unit Operation	Solid material transfer
Unit Process	NA
Hazard identification	Spillage, fire, explosion
Risk assessment	High (16-20)
Risk prevention	1. To follow check list. 2. Immediate manage
Risk control(3 Tier)	1. PPE 2. Suppression/Extinguishing 3. Zoning
5 \`S\` systems	1. Sort: Remove unwanted stuff 2. Set in order: keep things in place 3. Shine: clean all the values everyday 4. Standardize: get quality check by colleague 5. Sustain: get quality check by third party
Ergonomics	1. Provide hand gloves and other PPE 2. Provide pleasant environment

	3. Provide hand rails on the top of reactor 4. Provide path to easy escape, in case of gas leakage 5. Provide paintings/ maintenance regularly

1.5 Flow Chart Utilized to Evaluate Electrostatic Hazards:

The evaluation of electrostatic hazards is done as shown in fig 1.6,

- Initially the type of material involved is identified.
- Identify the type of material being handled (bulk powder or in-process equipment)
- Determine the minimum electrostatic discharge initiation threshold for the material.
- Test the electrostatic charging and storage characteristics of the material. This includes tests for charge generation (chute tests), electrostatic energy per unit mass generation, and charge decay rate.
- Measure the capacitance and resistance of in-process equipment.
- Calculate the charge decay rate.
- Determine the electrostatic charge energy balance in the process over time.
- Evaluate ESD conditions and circuit conditions.
- Identify potential hazards.
- If a problem is found, take corrective action.

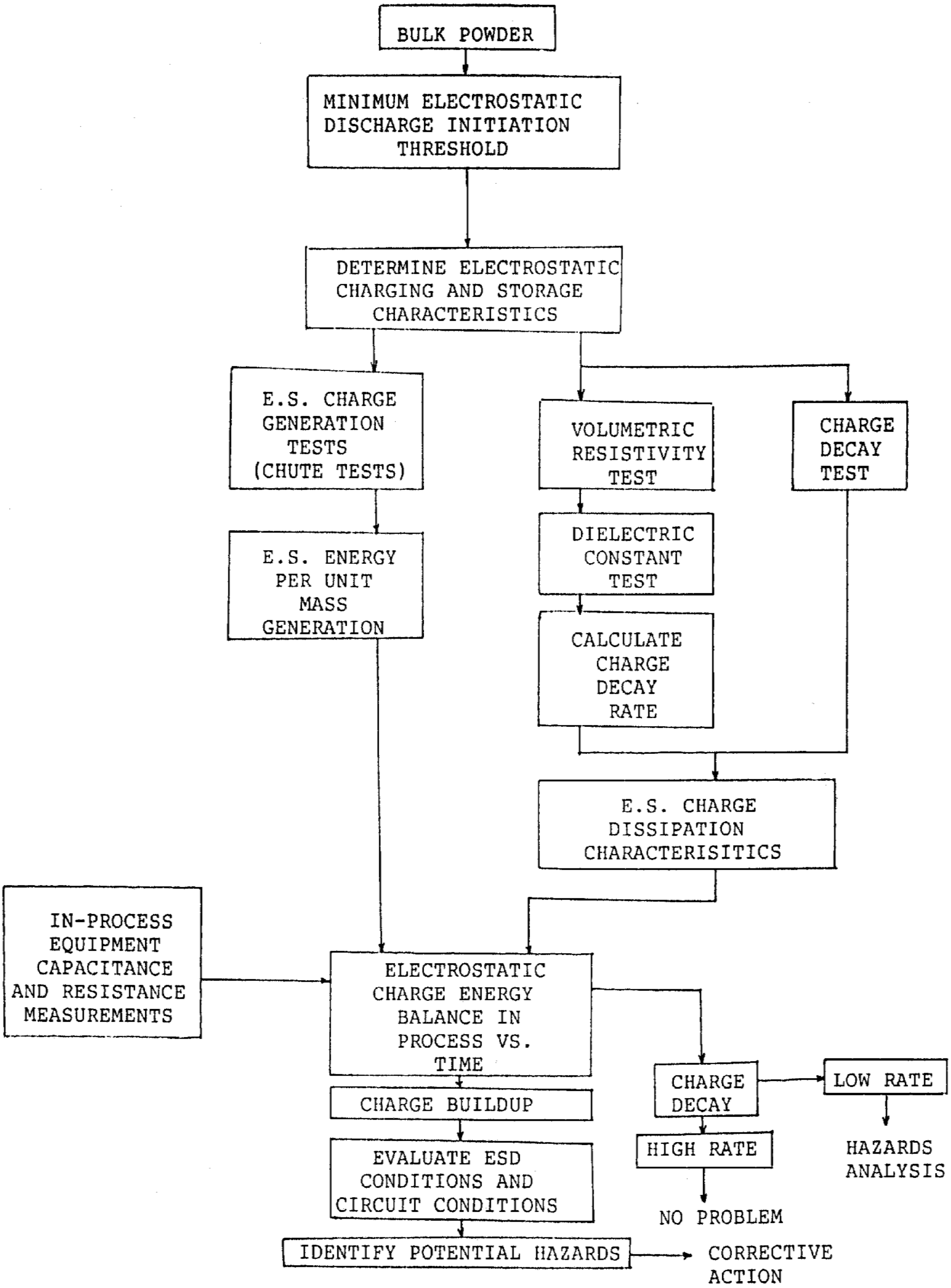

Fig 1.6 Process diagram to evaluate electro static hazards

1.6 OBJECTIVES:

1 To measure the Static Electricity of the critical powders.

2 To determine the densities of the powders such as Bulk Density, Tap Density. True Density,

3 To calculate the Porosity, Flowability, Thermal Conductivity, Electrical Conductivity of the powders.

4 To develop and implement a comprehensive material handling safety techniques.

5 To study the generation, dissipation and utilization of static electricity in human body.

CHAPTER II

LITERATURE REVIEW

M.Glor et.al., (May 1985) [3] studied powder handling processes, particles frequently come into touch with metallic surfaces, becoming electrically charged as a result of the contact electrification process. Because sliding/frictional contact is always present, such a contact electrification process is frequently referred to as triboelectrification. Triboelectrification is a sophisticated process in which charge exchange occurs between insulating surfaces. The concept of work function can be applied to certain insulator materials, particularly those that charge negatively, as many polymeric materials do. Surface charging is determined by surface condition, and some materials are sensitive to the presence of oxidising chemicals in the atmosphere, as well as moisture levels. To quantify the triboelectrification process, the kinetics of particle surface contact must be completely understood and the contact area precisely measured. The many types of discharges connected with powder handling and processing are discussed, with a focus on their phenomenological and theoretical descriptions, occurrence in practice, and incendivity. Special consideration is given to electrostatic phenomena that occur during the filling of big containers and silos**. [3]**

L. Perrin et.al., (May 2007) [4] suggested dust explosions are considered as serious industrial risks. Their analysis, prevention, and control require considerable attention. A dust explosion can result from a variety of factors. Static electricity is one type of igniting source. The existing safety standards for detecting electrostatic ignition hazards of dusts, such as electrical resistivity and charge decay time, are being applied in the process industries. However, the proposed protocols' standardisation suffers mostly from the lack of a comprehensive description of the experimental conditions. The content of the paper focuses on the effects of time, voltage, temperature, relative humidity, and dust compaction on the two preceding parameters. The acquired results clearly demonstrate the need to raise the current requirements. A proposal to complete the conditions of the normalised procedures is proposed. **[4]**

Joanne Peart et.al., (2001) [5] Powder electrostatics is an important and demanding part of powder processing. Particle-particle and particle-surface interactions cause particles to accumulate electrostatic charge during powder handling procedures such as particle size reduction, mixing, and powder transfer. Triboelectrification of powders is a complicated process since most powders are organic crystals that act as insulators under normal conditions. However, it is widely understood that charging happens as a result of electron transport across materials with varying electrical characteristics. Charge characteristics are influenced by particle size and shape, the type and work function of the contacting surface and particulate material, contact area and frequency, surface cleanliness, and ambient conditions. The effects of charge production on particle dynamics and powder behaviour are typically unanticipated. The Faraday pail or well is the traditional method for measuring electrostatic charge, with variations depending on the application. Many people consider electrostatics to be a nuisance and a hazard, but they play a significant and growing role in a variety of industrial applications such as powder coating, xerography, and pharmaceutical manufacturing. **[5]**

A.G. Bailey et.al., (May 1993) [6] The electrostatic charging of materials including webs, films, and powders caused by contact and triboelectric phenomena is discussed. Some of the issues that may occur in the sector as a result of material charges are addressed. The charging of webs moving over rollers, pneumatic movement of powder over pipes and into a silo, and charging of single polymer particles impacting on a metal surface are all discussed. Some of the issues that result from charge accumulation on the surface of materials are discussed. Some of these issues include powder flow disruptions and electrical discharges that result in fires and explosions. **[6]**

Kees van Wingerden et.al., (2011) Dust explosions and dust fires represent a considerable safety risk in process industry. Statistical records of dust explosions show that 32.7 % of these explosions are initiated by mechanical sparks or hot surfaces due to mechanical friction (Beck and Jeske, 1996). Laboratory investigations however show that direct ignition of dust clouds by mechanical sparks caused by friction processes is not that straightforward (Bartknecht, 1993; Rogers et al, 2006; Pedersen and Eckhoff, 1987). One possible explanation may be that dust clouds are ignited indirectly by burning dust layers which themselves got ignited by mechanical sparks. To investigate this in more detail ignition of dust layers by mechanical sparks was addressed in a comprehensive experimental program. **[7]**

CHAPTER III

MATERIALS AND METHODS

3.1 Materials required:

Glass ware: 250ml beakers-4, 1000ml beakers-2, 10ml measuring jars-3, Watch glass

Equipment: Two water baths, Clamp meter, Multi meter, Weighing machine.

Chemicals: Toluene, Finofibrate, Nitro compound, Chloro compound, Omeprazole, Esomeprazole, Pymol, Omeprazole sodium, Pantoprazole, Oseltamazor, Rabeprozole sodium.

3.2 Experimental method:

At Everest Organics, a comprehensive set of critical powders were collected, with 100 grams taken from each type found in various protection blocks as shown in fig 3.1

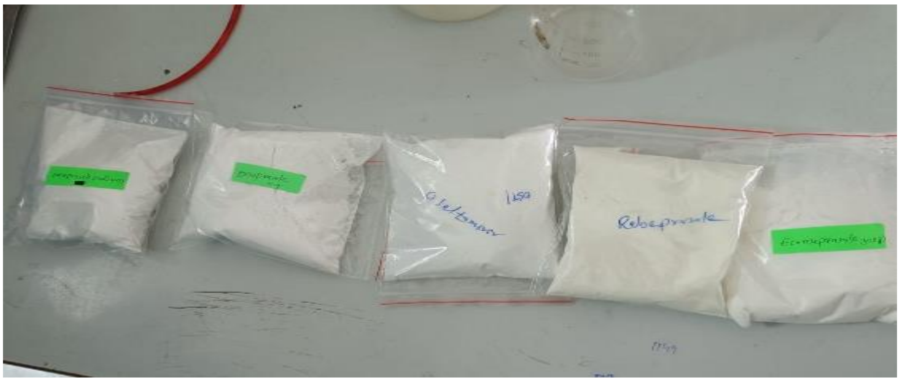

Fig.3.1: Collection of Chemical Powders

To determine the static electricity and characteristics of a powder sample, a specific quantity of the powder can be placed in a beaker, as illustrated in figure 3.2.

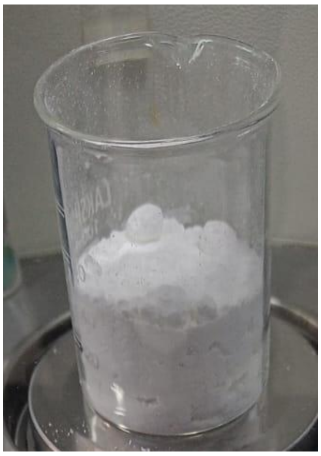

Fig.3.2: Powder taken into the beaker

3.3 EXPERIMENTAL PROCEDURE:

3.3.1 STATIC ELECTRICITY:

- Two 1000ml beakers were taken, ensuring they were clean and dry.
- The instrument named amprobe or multi-meter, which had two probes, was used. One probe was placed into the beaker, and another probe was connected to ground.
- The clamp meter, which also consisted of two probes, was used. One probe was placed into the beaker, and another probe was connected to the spatula used to transfer the powder into the beaker.
- The spatula connected to the clamp meter was used to measure the current.
- 100gm of powder was taken in one of the beakers and transferred into the other beaker using the spatula.
- When transferring the powder through the spatula, there was no change in the multi-meter.
- The deflection could be seen in a very minimal amount and was neglected.
- When transferring a bulk amount of powder into another beaker, there was deflection in the multi-meter.
- The process was repeated for each powder 4 to 5 times to obtain accurate readings

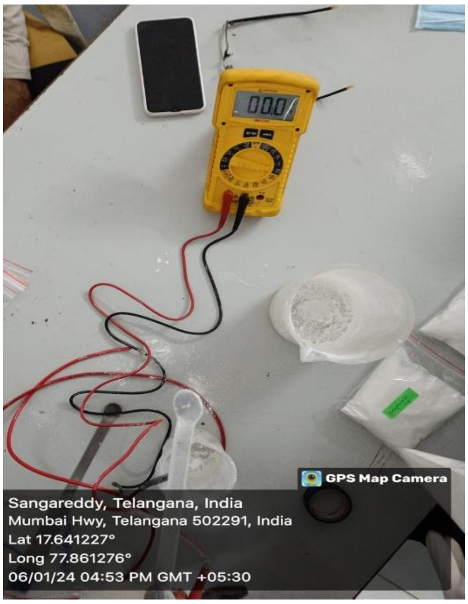

Fig 3.3 & 3.4 Static electricity

3.3.2 BULK DENSITY:

- The required materials were gathered, including a 10ml measuring jar and 4.5ml of the powder to be tested.
- The measuring jar was ensured to be clean and dry before use.
- Using an analytical balance, 4.5ml of the powder sample was accurately weighed, and the exact weight was recorded for future reference.
- The pre-weighed powder was carefully poured into the measuring jar, taking precautions to avoid spillage and ensuring even settling.
- A spatula or a straight-edged tool was used to level the powder surface inside the measuring jar, crucial for obtaining accurate bulk density measurements.
- The initial volume reading on the measuring jar was noted, indicating the volume occupied by the powder before any compaction.
- If specified in the testing procedure, a specified number of taps or a vibration apparatus was used to lightly compact the powder. This step was optional and depended on the testing standards or requirements.
- After any optional compaction step, the final volume reading on the measuring jar was recorded, reflecting the volume occupied by the powder after compaction.
- The measured values were substituted into the formula to calculate the bulk density of the powder.
- For reliable results, the entire procedure was repeated at least two more times with fresh samples of the powder, and the average bulk density was calculated from the multiple measurements.
- All measurements, including initial and final volumes, weights, and calculated bulk densities, were documented. The average result and any relevant observations were clearly presented.
- All equipment was cleaned thoroughly after each measurement to prevent contamination in subsequent tests.
- Bulk mass = weight of measuring jar with material – weight of empty jar
- Bulk density = $\frac{Bulk\ mass\ (gm)}{Bulk\ volume (ml)}$ Equation 1

3.3.3 TAPPED DENSITY:

- 4.5 ml of the powder was accurately weighed using a precision balance.
- The weighed powder was carefully transferred into the measuring jar.
- The initial volume of the powder in the measuring jar was noted. This served as the starting point for tap density determination.
- The measuring jar was securely held, and it was subjected to a specified number of taps. In this case, the jar was tapped 200 times.
- After the tapping process, the volume of the powder in the jar was measured again. This represented the final volume after tapping.
- The initial volume, final tapped volume, and calculated tap density were documented in the experimental records. • The tap density was calculated using the formula.
  - Tap density= $\frac{Tapped\ mass(gm)}{Tapped\ volume(ml)}$ Equation 2

  Taped mass= weight of the jar with material after tapping – weight of the empty jar
- Check the volume after taping it would be your tapped volume.
- Repeat the procedure to get the accurate readings and calculated the average tap density from multiple trials

3.3.4 TRUE DENSITY:

- Begin by accurately weighing the provided powder using an analytical balance. Record the mass of the powder, ensuring precision in measurement.
- Carefully transfer the weighed powder into the measuring jar. Handle the powder with care to avoid spillage and maintain accuracy in the measurement.
- Using a graduated cylinder or a pipette, measure precisely 4.5ml of toluene. Toluene is commonly used in these measurements due to its ability to wet most powders, ensuring a uniform volume.
- Pour the measured toluene into the measuring jar containing the powder. Ensure thorough mixing to achieve a homogeneous mixture.
- Gently tap the measuring jar on a solid surface to eliminate any trapped air bubbles within the powder-toluene mixture. This step helps in achieving a more accurate measurement of volume.
- After tapping, allow the powder-toluene mixture to settle for a 5min or sufficient period. This allows the powder particles to pack more closely, minimizing void spaces within the mixture.
- Carefully observe the settled volume of the mixture in the measuring jar. Note the volume reading, ensuring that it accurately represents the settled state of the powder-toluene mixture.
- For increased accuracy, consider repeating the procedure multiple times and calculating the average true density. This helps mitigate any potential errors in measurement.
- Record all measurements, observations, and calculations in a detailed and organized manner. Include information such as the type of powder used, the ambient conditions, and any other relevant details.
- The true density can be calculated using the formula:

  $$\text{True Density} = \frac{True\ mass\ of\ powder(gm)}{True\ volume(ml)}. \qquad \text{Equation 3}$$

- Substitute the measured values into the formula to obtain the true density of the powder.

3.3.5 POROSITY:

To find porosity by using the following formula:

- Porosity = = 1- $\frac{buik\ volume}{tapped\ volume}$ Equation 4

Ensure that the densities are measured using consistent units (e.g., grams per cubic centimeter) for accurate results. This formula helps quantify the volume percentage of void spaces (porosity) within a material based on its overall density and the density of its solid particles.

3.3.6 FLOWABILITY:

To find flowability by using the following formula:

Flowability = 1- $\frac{tapped\ density}{bulk\ density}$ Equation 5

3.3.7 THERMAL CONDUCTIVITY:

- Two 250ml beakers were taken and ensured to be clean and dry.
- 100ml of powder was taken to find its melting point.
- The powder was added into the beaker, and its temperature was measured using the thermometer, noted down as t1.
- Two water baths were prepared and maintained at a temperature lower than the powder's melting point.
- The beaker with the powder was placed in one of the water baths for 10-15 mins.
- The temperature of the powder was checked, and it was noted down as t2.
- The same procedure was followed for the other water bath to check accuracy.
- After finding t1 and t2, the thermal conductivity was found using the formula.
- **k=** $\frac{\boldsymbol{Q}.\boldsymbol{L}\ \ (\boldsymbol{W})}{\boldsymbol{A}.\boldsymbol{\Delta T}\ (\boldsymbol{mk})}$ Equation 6

Where, Q = power (W)

L= length of the beaker (m)

A= Area of cross sectional area (m^2)

ΔT = temperature difference (t_1-t_2)(k)

Fig 3.5 Powders in water bath

3.3.8 ELECTRICAL CONDUCTVITY:

- 250ml beaker taken it was completely cleaned and dried. This step was crucial because moisture can significantly affect electrical conductivity measurements.
- Next, they carefully added 100ml of the powder to the clean, dry beaker. To minimize spillage during this step, they considered using a funnel.
- The multimeter was then set to the millivolt (mV) range. This setting was chosen because it's appropriate for measuring the low potential differences (voltages) expected in low-conductivity materials like powders.
- The two probes of the multimeter were carefully inserted into the powder sample. Then there was good contact between the probes and the powder particles.
- To enhance particle-to-particle contact and facilitate conduction, the powder was gently stirred or agitated slightly with the probes. Then observed the multimeter reading.
- If there was no deflection or change in the reading, even while moving the probes around within the powder, it suggested negligible electrical conductivity.
- For further confirmation, the researchers might have considered repeating the measurement with a fresh sample of the powder.
- Depending on the experiment's design, they could have taken multiple readings at different locations within the powder bed to account for potential variations.
- Throughout the process, all observations and measurements, including the final conductivity value (if obtained), would have been documented for later analysis.

3.3.9 To develop and implement a comprehensive Material Handling Safety techniques.

1. **Grounding:**

   Grounding is the safest way to dissipate static electricity in industrial environments. It involves connecting conductive objects to the earth using wires, clamps, or clips. The conductor provides a path to the ground to drain static charge as it is produced.

2. **Humidifer:**

   Humidifiers can help reduce static electricity by adding moisture to the air and equalizing electrical charges. Static electricity is more likely to occur in dry air, especially during the winter. To prevent static,should aim for a relative humidity level of at least 45%. A safe humidity level is generally around 40-60%.

3. **Wear low static shoes & fabrics**

3.3.10 To study the generation, dissipation and utilization of static electricity in human body.

1. **GENERATION:**

   In our ancestral past, humans lived in constant physical contact with the earth, allowing electrical charges to dissipate naturally. However, modern life with shoes and insulated homes disrupts this grounding effect. This lack of grounding may lead to an accumulation of static charges in the body, potentially interfering with bioelectrical functions and contributing to issues like stress and fatigue. While the human body doesn't generate static electricity itself, it can store charges picked up through movement, touching objects, or interacting with certain fabrics. For instance, walking on carpets can cause your body to accumulate extra electrons.

2. **DISSIPIATION:**

- **Direct Contact:** When a person touches a grounded object, such as a metal doorknob or walks barefoot on the ground, excess charge flows through their body and into the object. This can result in a brief tingle or spark as the charge neutralizes.
- **Indirect Contact:** Brushing against an object, like clothes on a chair, transfers some of the object's charge to the body. This can happen unnoticed, slowly balancing the charge.
- **Air Ionization:** In dry environments, static charges leak off the body slowly through a process called air ionization. Air molecules surrounding the body gain or lose electrons, balancing the charge on the body's surface.

- **Humidity:** Higher humidity increases the conductivity of air, allowing static charges to dissipate more readily through the air molecules. This is why people experience fewer shocks in humid weather.

3. **UTILIZATION:**

A static observer device could be a device crafted to over see or monitor a specific area or surroundings without mobility. It might incorporate two copper plates, an empty condenser, and small wire circuits. The vacant condenser is connected to the copper plates via wires. These copper plates detect static electricity from the human body, which is then discharged into the empty condenser.

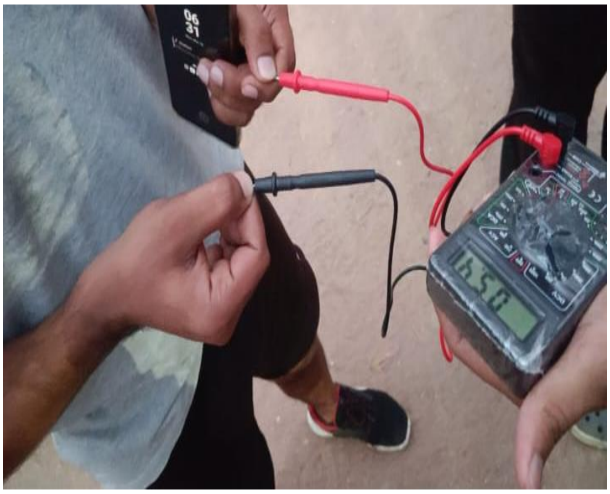

Fig 3a Measuring static electricity generated in the body

Fig 3b Static absorber dissipation system

Fig 3.6 Dissipation of static elelctricity

CHAPTER –IV

RESULTS AND DISCUSSIONS

The static electricity data shown in Table 4.1 indicates a significant generation of, 30.2 millivolts of electricity for Omeprazole which suggests a high likelihood of fire. Similar to this, testing of the Omeprazole sodium, static electricity data indicates generation of 40.2 millivolts, indicating a likelihood of fire. It can be noticed in table 4.1 that Rabeprozole has the propensity to produce the highest amount of static electricity (77.2 millivolts) out of all the solid compounds.

Table 4.1 SPECIFIC DATA FOR STATIC ELECTRICITY:

S. No	Compound name	Weight of the compound (gm)	Voltage generated (milli volts)
1.	Omeprazole	100	30.2
2.	Omeprazole sodium	100	40.6
3.	Oseltamazor	100	24.9
4.	Rabeprozole sodium	100	77.2
5.	Esomeprazole	100	22.9
6.	Pantoprazole	100	58
7.	Nitro compound	100	23.9
8.	Chloro compound	100	18
9.	Pymol	100	16
10.	Finofibrate	100	68

Pymol produced the least amount of static electricity at 16 millivolts. With the exception of Pantoprazole, other powders are found to be cohesive, with flowability values less than 1.29. This suggests that the proper gliding component should be added to allow for free flowing during phasing.

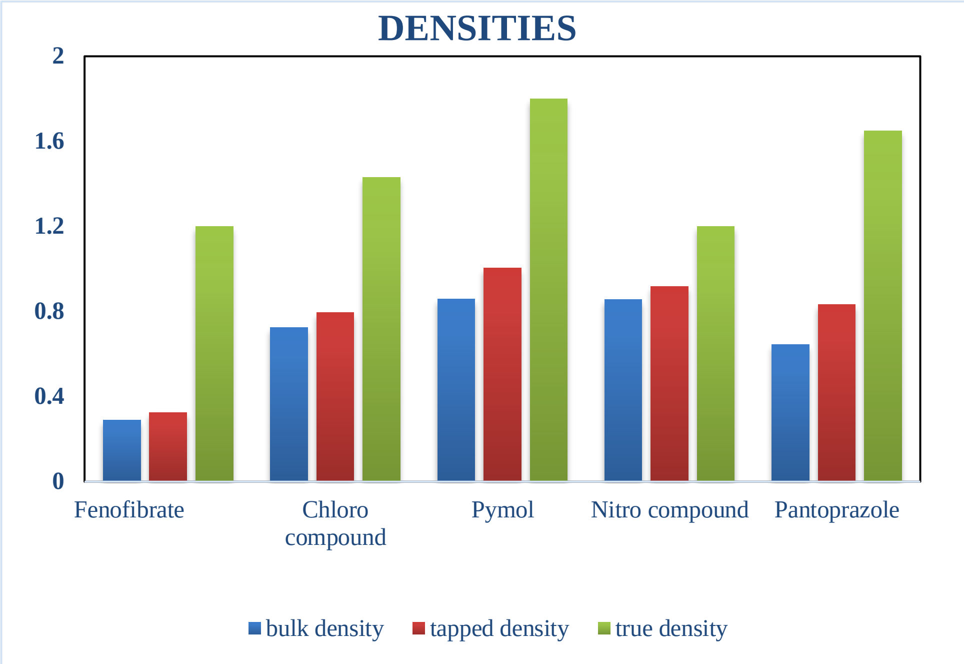

Fig 4.1 Difference of densities

Pymol has the highest true density (1.8 gm/ml) among all the compounds, Its molecules were likely small and packed tighter, like spheres and stronger attractions between them, pulling them closer.

When comparing the bulk densities and porosity of all compounds, Fenofibrate has having low bulk density and high porosity because bulky group prevents them from packing tightly, creating voids or empty spaces within the powder. This contributes to the high porosity and low bulk density

For Chloro compound, Pymol, Nitro compound, Pantoprazole having the high bulk density and low porosity because, the compound is composed of smaller, more regularly shaped particles that pack together efficiently with minimal empty space (porosity). Additionally, strong attractive forces between these particles pull them closer, further reducing void space and contributing to the high bulk density.

Low porosity and high bulk density it can vary depending on the specific material and its composition.

Table 4.2 CHARACTERISTICS OF POWDERS:

S. No	Compound name	DENSITIES			Porosity	Flowability	Thermal conductivity(W/m^{-1}K^{-1})	Electrical conductivity(S/m)
		Bulk density(gm/ml)	Tapped density(gm/ml)	True density(gm/ml)				
1.	Finofibrate	0.29	0.325	1.2	0.8	1.12	0.89	Negligible
2.	Chloro compound	0.724	0.795	1.43	0.45	1.09	0.54	Negligible
3.	Pymol	0.859	1.005	1.8	0.455	1.16	0.66	Negligible
4.	Nitro compound	0.856	0.9190	1.2	0.25	1.07	0.97	Negligible
5.	Pantoprazole	0.646	0.834	1.65	0.502	1.29	0.10	Negligible

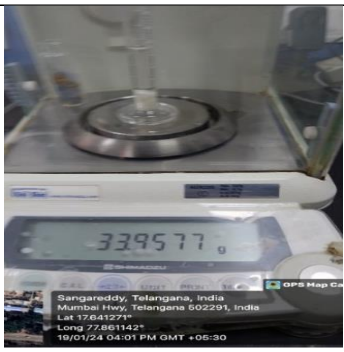 **Fig 4(a)** Choloro compound	 **Fig 4(b)** Pymol
 **Fig 4(c)** Nitro compound	 **Fig 4(d)** Pantoprazole

Fig 4 (a), (b), (c), (d) True Densities of powders along with their weights

- In simple terms, powders with higher melting points tend to have lower thermal conductivity because their particles don't melt easily and therefore hinder the transfer of heat. Conversely, powders with lower melting points tend to have higher thermal conductivity because their particles melt more readily, allowing heat to move more easily through the material. Electrical conductivity refers to a material's capacity to carry electric current. In insulators, such as most powders, there are few free electrons to conduct electricity. When the probes hit the powder, the multimeter does not respond, indicating that the conductivity is poor.

- Grounding is like giving the static electricity a safe path to follow. It involves connecting the materials or equipment to the ground, which is a big, safe reservoir for electricity. By doing this, any static electricity that builds up can flow harmlessly into the ground, preventing sparks and keeping everyone safe.

- Static electricity in the human body can be safely released through methods like grounding. This discharged energy holds potential for powering applications. Proper dissipation of static electricity within the body is essential for maintaining bodily functions like proper function of heart rate.

CHAPTER-V

CONCLUSIONS

1. The measurement of static electricity in critical powders provides valuable insights into their processing properties, aiding in the optimization of manufacturing processes and ensuring safety.
2. Determining the densities of powders, including bulk control over material handling, packaging, and density, true density, and tap density, enables precise storage conditions, contributing to product quality and process efficiency.
3. Powders with higher melting points have lower thermal conductivity because their particles do not melt quickly, reducing heat transfer. Powders with lower melting points tend to have higher thermal conductivity because their particles melt more readily, allowing heat to travel more easily through the material. Electrical conductivity depends on the ability of a material to carry electric current. In insulators like most powders, there are minimal free electrons to conduct electricity. The lack of response on the multimeter when the probes touch the powder signifies this low conductivity.
4. Grounding also called earthing, is the safest way to dissipate static electricity in industrial environments. It involves connecting conductive objects to the earth using wires, clamps, or clips. The conductor provides a path to the ground to drain static charge as it is produced.
5. Static electricity is dissipated in human body through various mechanisms such as grounding. The dissipated energy can be utilized for powering. Dissipating static electricity within the body is crucial for proper body function.

CHAPTER - VI

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APPENDIX

IUPAC names of materials:

1. **Fenofibrate:** propan-2-yl 2-[4-(4-chlorobenzoyl)phenoxy]-2-methylpropanoate.
2. **Pantoprazole:** 2. RS)-6-(Difluoromethoxy)-2-[(3,4-dimethoxypyridin-2-yl)methylsulfinyl]-1H-benzo[d]imidazole
3. **Pymol:** 4-[2-(2-Amino-4,7-dihydro-4-oxo-1H-pymol[2,3-d] pyrimodin-5-yl)ethyl]benzoic acid -
4. **Nitro compound:** 1-chloro-4-methyl-2-nitrobenzene is -xA0-1-chloro-4-methyl-2-nitro benzene-xA0-
5. **Chloro compound:** chloro(2,2,4,4-tetramethylpiperidinyl-1-oxo-O,N)(triphenylphosphine)palladium(II)-

Safety data sheet of Omeprazole

Trade name: **Omeprazole**

IUPAC: 6-methoxy-2-[(R)-[(4-methoxy-3,5-dimethyl-2-pyridinyl)methyl]sulfinyl]-1H-benzimidazole, monosodiumsalt.

Application of the the material: This product is for research use - Not for human or veterinary diagnostic or therapeutic use.

1. PERSONAL PROTECTION EQUIPMENT (MEN):

- Eyes: Protect your eyes from chemical powder contact by donning safety goggles. If exposure occurs, rinse eyes right away with clean water and get medical help if irritation doesn't go away.
- Nose: To avoid breathing in chemical powders, wear a mask or respirator. Make sure the workspace has enough ventilation to reduce exposure to airborne pollutants.
- Mouth: To avoid ingesting chemical granules, stay away from areas where eating, drinking, or smoking are permitted. If need, cover your mouth with a mask.
- Skin: To avoid coming into touch with chemical powders on your skin, wear gloves and protective clothes. After handling, properly wash your hands and any exposed skin with soap and water.
- Ears: Although you are not in direct contact with chemical powders, you can shield your ears from potential injury by keeping the environment as safe as possible.

2. **MATERIAL HANDLING AND STORAGE:**

Industries must carefully evaluate the type of chemical, its reactivity, temperature sensitivity, and potential risks when storing chemical powders. Here are a few broad recommendations:

Container Selection:

Use glass, stainless steel, or high-density polyethylene (HDPE) containers if possible. These materials are suitable with the particular chemicals being stored. Steer clear of anything that might react with the chemicals.

Segregation:

To avoid unintentional interactions, store substances apart according to their compatibility and reactivity. Use spaces set aside for particular chemical classes or segregation cabinets.

Ventilation:

To avoid the accumulation of hazardous gases or fumes, make sure storage rooms have enough ventilation. Install ventilation systems suitable for the particular chemicals being kept in storage.

Temperature Control:

To avoid deterioration or volatility, store substances at the proper temperature. Certain chemicals might need to be refrigerated or stored in rooms with controlled temperatures.

Safety precautions:

Put in place safety precautions in case of an accident, such as emergency showers and eyewash stations, spill containment systems, and fire suppression systems.

3. **MACHINES:**

- Forklifts:
  Forklifts equipped with specialized attachments can lift and dump materials from containers or bins.
- Tippers and Dumpers:
  These specialized machines are designed specifically for dumping materials from containers, bins, or hoppers.
- Material Handling Cranes:
  Cranes equipped with grabbers or buckets can lift and dump bulk materials, especially in environments like ports or construction sites.

4. **PROPERTIES OF MATERIAL COMPOUND:**

- Melting point: >156°C
- Boiling point: 599.991°C at 760mmHg
- Flash point: not determined
- Auto ignition: not available
- Reaction with air: - Typically stable in air.
  Reaction with water: Generally soluble in water, but chemical stability may vary.
- Reaction with other common chemicals: Interactions may occur; specific details depend on the chemical nature of the substances involved.
- Static Electricity: 40.6 millivolts

5. **FIRST AID MEASURES:**

Inhalation: Supply fresh air; consult doctor in case of complaints.

Skin contact: Generally, the product does not irritate the skin.

Eye contact: Rinse opened eye for several minutes under running water.

Swallowing: If symptoms persist consult doctor

6. **PROBABILITY OF FIRE:**

The probability of fire from chemical powders in industry depends on various factors:

- Type of chemicals used, storage conditions, handling practices, and preventive measures in place

- Implement proper storage and handling procedures to minimize the risk of fires.
- Consulting with safety experts and regulatory guidelines can help ensure a comprehensive understanding of potential risks and appropriate preventive measures.

7. **FIRE EXTINGUISHERS:**

Suitable extinguishing agents:

- Use fire fighiting measures that suit the environment.
- A solid water stream may be inefficient.
- Advice for fire-fighters.
- Protective equipment