# DETERMINATION OF MICROPLASTICS IN TERMITES (DICTYOPTERA: ISOPTERA).

by

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## STUDENT DECLARATION

I declare that the project work presented in this thesis entitled "DETERMINATION OF MICROPLASTICS IN TERMITES (DICTYOPTERA: ISOPTERA)" in the partial fulfillment of the requirements needed to be awarded a degree of Applied Science (Natural Resources Sciences) is a record of an original work is my own work under the guidance of Dr. Norashikin Fauzi. Furthermore, the findings presented in this thesis have not been submitted for consideration for a degree or diploma from any other university or institute.

Signature:

Name: NOR HANISHA BINTI MUHAMMAD RAPI

Date: 18/8/2024

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**Determination Of Microplastics In Termites (Dictyoptera: Isoptera).**

## ABSTRACT

This study was conducted to determine the presence of microplastics in termites *(*Dictyoptera: Isoptera*)*. This study also aims to characterize the microplastics within termites, collected in Kampung Bukit Jering, as well as to verify the presence of microplastics in termites. Microplastics have already been recognized as a significant environmental and human health issue. Microplastics from termite samples were extracted from dead coconut trunks and then characterized using ATR-FTIR to determine the microplastic composition. Based on the spectrum, the extracted microplastics in each samples were confirmed as Polyethylene and Polyester. Then, an optical microscope was used to determine the color and shape of the microbeads. Microplastics found in the external termite's body parts are fibers. Hence, this study proved the presence of microplastics in termites.

Keywords: Termites, dead coconut trunk, ATR-FTIR, optical microscope, polyethylene, polyester, fibers

**Penentuan Mikroplastik Dalam Anai-anai (Dictyoptera: Isoptera).**

## ABSTRAK

Kajian ini dijalankan untuk menentukan kehadiran mikroplastik dalam anai-anai (Dictyoptera: Isoptera). Kajian ini juga bertujuan untuk mencirikan mikroplastik dalam anai-anai, yang dikumpulkan di Kampung Bukit Jering, serta untuk mengesahkan kehadiran mikroplastik dalam anai-anai. Mikroplastik telah pun diiktiraf sebagai isu alam sekitar dan kesihatan. Mikroplastik daripada sampel anai-anai telah diekstrak daripada batang pokok kelapa yang telah mati dan kemudian dicirikan menggunakan ATR-FTIR untuk menentukan komposisi mikroplastik. Berdasarkan spektrum, mikroplastik yang diekstrak dalam setiap sampel telah disahkan sebagai Polietilena dan Poliester. Kemudian, mikroskop optik digunakan untuk menentukan warna dan bentuk microbeads. Mikroplastik yang terdapat pada bahagian badan anai-anai luaran ialah gentian. Oleh itu, kajian ini membuktikan kehadiran mikroplastik dalam anai-anai.

Kata kunci: Anai-anai, batang kelapa mati, ATR-FTIR, mikroskop optik, polietilena, poliester, gentian

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

Microplastics are tiny plastic particles that are released into the environment as a result of plastic pollution. Microplastic pollution has been widely studied because of its various adverse effects on the environment and marine life. The Solid Waste Management and Public Management Corporation (SWCorp) recorded a total of 101,949 tons or 13 percent of the waste produced by the residents of Kuala Lumpur and Putrajaya in 2021 as plastic (Berita Harian, 2024). Nowadays, the demand for plastics keeps growing every year, it is because of their many uses and affordable manufacturing cost (Tomasovic, 2014). Typical plastics are used in sectors such as polystyrene and polyethylene (PE) (PS), nylon, polyamide, and polyvinyl chloride (PVC). However, plastics are typically known as non-biodegradable materials since they take a very long time to break down.

Termites play important roles in the ecosystem. For example, termites help with soil structure, nutrient cycling, and the breakdown of dead plant matter. Microplastics may have an impact on termites' ecological roles and the condition of ecosystems if they consume them. Then, many other kinds of animals, such as birds, reptiles, and other insects, eat termites. Microplastics found in termites have the potential to affect humans and other higher trophic levels by moving up the food chain. Termite microplastic research can be used as a bioindicator of pollution in the environment. The presence of microplastics in these insects can shed light on the degree of plastic contamination in the surrounding ecosystem.

The capacity of termites to break down cellulose in wood has been well-documented, and this ability is essential to their ecological function in the breakdown of lignocellulosic materials. But even while their capacity to digest cellulose has been thoroughly studied, there has been a noticeable lack of research on the possible build-up of microplastics within termite bodies. Termites usually live in soil habitats that are becoming more and more contaminated with microplastics as a result of widespread pollution in the environment. Given this context, while foraging in such contaminated soils, termites may unintentionally consume microplastics. This begs important concerns about the possible concentration and prevalence of microplastics in termite populations. To determine whether termites may gather microplastics from their surroundings and to assess the potential effects on their well-being and ecological relationships, this possibility must be thoroughly investigated.

Therefore, to determine the level of microplastic accumulation in termites, measure any levels found, and investigate the ecological effects of such contamination, thorough research is needed. This research would greatly advance our knowledge of how microplastic contamination affects soil-dwelling creatures and the dynamics of larger ecosystems.

## 1.2 Problem Statement

Termites has been displays to contain cellulose derived from wood, indicating their role in the degradation of lignocellulosic materials. Given that termites live in soil habitats that are known to be contaminated with microplastics, it is unknown if they also accumulate microplastics. This begs the question of whether termites may consume or gather microplastics from their environment, hence requiring additional research into the possibility of microplastics in termite populations.

## 1.4 Objective

1. To determine the occurrence of microplastics within the termites.
2. To characterize the microplastics within the termites.

## 1.5 Scope of Study

The scope of this study was established by several essential elements that together provide a thorough assessment of termite contamination with microplastic and its ecological consequences. The study's primary focus was on termites living in residential areas with soil environments known to be polluted with microplastics. It entailed finding and measuring the different kinds, sizes, and concentrations of microplastics inside termite bodies. Through the use of a variety of analytical methods, such as chemical assays and microscopy, the study offered a comprehensive understanding of the occurrence of microplastic in soil-dwelling species and their surroundings.

### 1.6 Significant of Study

This study holds considerable significance for both the community and local authorities by addressing the emerging issue of microplastic contamination in soil-dwelling organisms, specifically termites. The results may increase public awareness of the wider effects of microplastic pollution, which will affects the aquatic environments and terrestrial ecosystems. The fact that termites and other soil-dwelling creatures may accumulate microplastics proved the pervasive nature of this pollutant and the possible harm it may do to local biodiversity and ecosystem health.

# CHAPTER 2

# LITERATURE REVIEW

| Year | Author | Previous studies |
|---|---|---|
| 2021 | Lewis Revely, Seirian Summer, & Paul Eggleton | The Plasticity and Developmental Potential of Termites. |
| 2021 | Hui Wei, Lizhu Wu, Ziqiang Liu, Muhammad Saleem, Xuan Chen, Jiefen Xie & Jiaen Zhang. | Meta-analysis reveals differential impacts of microplastics on soil biota. |
| 2021 | Pavani Dulanja Dissanayake, Soobin Kim& Md Niamul Hague | Effects of Microplastics on The Terrestrial Environment: A Critical Review |
| 2023 | Juan-Ying Li, Yang Yu, Nicholas J. Craig, Wenhui He & Le Su | Interactions between microplastics and insects in terrestrial ecosystems—A systematic review and meta-analysis |

| | | |
|---|---|---|
| 2023 | Jiangiang Zhu, Pengfei Wu, Nan Zhao, Shengtao Jiang, Huayue Zhu & Hangbiao Jin | Microplastics in Terrestrial Insects, Long Horned Beetles (Coleoptera: *Cerambycidae*), from China |

Table 2.1: The list of previous studies about microplastics.

## 2.1 Definition of microplastics.

The worldwide production of plastics has risen significantly over the past few centuries. Since the early 1970s, microplastic particles have been in the marine environment. (Carpenter and Smith Jr, 1972). Thus, plastic usage has grown exponentially since the 1950s (Vaid et al., 2021). The situation is made worse by the difficulty of their natural breakdown, which ultimately leads to the accumulation of plastic in practically every environment (Mcnutt, 2017). The type of plastic that has a high degree of crystallinity (30 - 50%) is polyethylene terephthalate (PET). It is one of the main causes of their slow rate of microbial degradation. They will probably take more than 50 years to decompose in the natural environment, and hundreds of years if they are thrown into the ocean due to the lower temperature and reduced oxygen content (Mohanan et al., 2020). Petroleum-derived (petro-) polymers such as polyethylene (PE), polyethylene (PET), polyurethane (PU), polystyrene (PS), polypropylene (PP), and polyvinyl chloride (PVC) are very resistant to natural biodegradation processes. Depending on the kind of polymer and the surrounding conditions, plastics have environmental half-lives that can range from days to centuries (Ward et al., 2019). The majority have not been examined scientifically. Andrady (2017) claims that most plastic fragmentation occurs on land due to factors like frictional forces, UV exposure, and higher ambient temperatures. Microplastics are tiny plastic particles that are less than five millimeters and can be found in a wide range of situations. The main sources are plastic production, weathering of larger plastics, use of microbeads in personal care products, and microplastic fibers shedding from synthetic garments after washing (Bhat et al., 2022a; Habib et al., 2022).

## 2.2 Definition of Termites

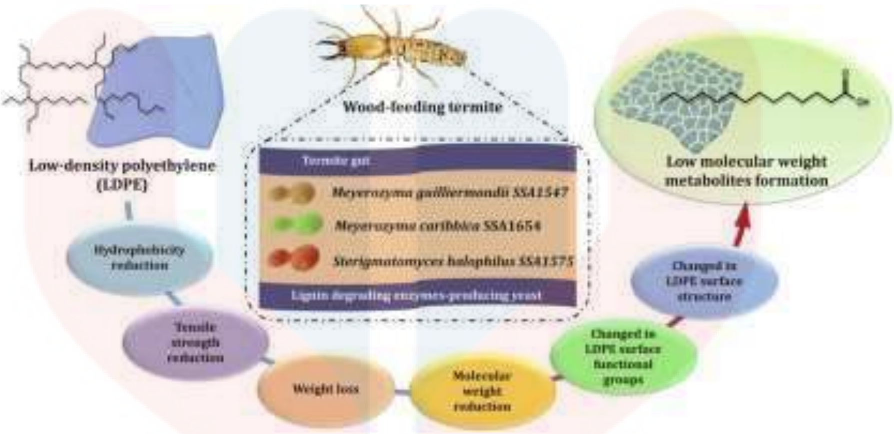



Figure 1: The Microplastics in Termites.

Termites are known as social cockroaches (order Blattodea), sister to the sub- social reach genus, *Cryptocercus* (Lo et al., 2000; Inward et al., 2007; Bourguignon et al., 2015; Bucek et al., 2019; Evangelista et al., 2019). As important cellulose decomposers in warmer environments, termites can consume a variety of materials, including grass, wood, soil, plastic, and leaf litter (Takamura, 2001). (Eggleton, 2011). Termites have important roles in improving the drought resistance of ecosystems (Ashton et al., 2019). For example, termites play a major influence on soil chemical and physical structure, nitrogen and carbon cycling, plant decomposition, and microbial activity (Holt and Lepage 2000). Termites are the most significant invertebrate decomposers in the tropics, but they only have a limited ecological effect in temperate zones (Bignell and Eggleton 2000; Bignell et al. 2011). In tropical environments, termites typically comprise more than 10% of the overall biomass of animals and up to 95% of the biomass of soil insects (Jones and Eggleton 2000) and are thought to improve the productivity of ecosystems (2016) Bourguignon et al.

In the year of 1960, scientists recorded the first piece of evidence for plastics and insects interactions (Yang Yu et al., 2023). It is confirmed that when groups of insects were found destroying packing materials. Microplastics obtained from anthropogenic contributions have a high probability of interacting with insects. Some species, like termites and cockroaches, cockroaches and termites, have evolved to live with us and actively enter indoor spaces.

## 2.3 Effects of microplastics on the ecosystem.

As of 2020, the world's annual production of plastic was 350 metric tonnes, and this number is predicted to rise in the years to come (Borrelle et al., 2020; Maity and Pramanick, 2020). Global environmental matrices have shown a high prevalence of microplastics (MPs), which are plastic particles with a diameter of 1 μm–5 mm (Alimi et al., 2018). (Hale et al., 2020; Mendoza et al., 2021; Qu et al., 2022; Yuan et al., 2022; Zhu et al., 2022). MPs are usually found in the environment as a result of both the breakdown of bigger plastic trash and the use of MPs in various applications (An et al., 2020; Xu et al., 2020; Zhang et al., 2019).

Over the past two decades, an ever-growing number of studies have been carried out to characterize the source, sink, and ecological effects of MPs in ecosystems (Sorensen and Jovanovic, 2021). Ocean has been described as an ecosystem that has a large amount of plastics (Cózar et al., 2014, Eriksen et al., 2014, Thompson et al., 2004).

Moreover, when microplastics land on soil surfaces, external factors including bioturbation and human activity can instantly integrate them into the soil matrix. Changes in the texture and structure of the soil may result from this assimilation. Due in large part to the fact that commercial polymers are typically less thick than ordinary soil particles, visible changes in soil composition and structure can be seen in heavily polluted soils. Important characteristics that can be utilized to assess changes in soil physical properties brought on by plastic pollution include polymer kinds, forms, and shapes (Lehmann et al., 2021; Wang et al., 2021a, Wang et al., 2021b, Wang et al., 2021c). Microplastics can modify the structure, porosity, and water-retention capacity of soil. Plant development and soil fertility may be impacted by this. Plant nutrient availability may be impacted by the adsorption and movement of nutrients in the soil by microplastics. Changes in soil fertility and plant development may result from this.

### 2.4 Effects of microplastics on living biota

The living things in the ecosystem are especially harmed by microplastics and their broken products, such as MPs (e.g., Andrady, 2011; Cole et al., 2011; Wright et al., 2013). After being consumed, MPs and the related hazardous substances are most likely to harm organisms (Andrady, 2011, Cole et al., 2013, Wright et al., 2013). For example, they could build up in the digestive system and cause obstructions, internal damage, and difficulties with eating and digesting. MPs and NPs also may have harmful consequences on human health. It is commonly recognized that plastic additives are extremely carcinogenic and harm organs. According to Wang et al. (2016), the carcinogenic monomers of PS polymer can cause reproductive disorders and cancer in humans, rodents, and invertebrates. Consuming contaminated food or water can cause the ingestion of microplastics into the human body. For instance, it has been discovered that drinking water sources are affected and that seafood contains microplastics.

The pedosphere is a potentially significant sink to receiving and reserving MPs, as has been made clear in several recent reviews (de Souza Machado et al., 2018a, Helmberger et al., 2020, Hurley and Nizzetto, 2018). Terrestrial ecosystems are similarly subject to MP inputs. Since Rillig (2012) emphasized the need to investigate soil microplastics, microplastics in soil have drawn a lot of interest as a recently developing hotspot of ecological and environmental studies (Fig. 1b). Since soil has various aquatic systems that sustain a variety of aquatic creatures in the water layer on the soil surface, many concepts developed for aquatic ecosystems may also apply to soil ecosystems (Rillig, 2012). Soil components play the important role that drives a majority of ecosystem processes and functions (Crowther et al., 2019, Delgado-Baquerizo et al., 2017, Liu et al., 2019b), The accumulation of MPs in soil may have an impact on soil biota, potentially causing harm and inhibition to earthworm functions, deadly toxicity to fungi, and changes to soil microbial communities (Browne et al., 2013, de Souza Machado et al., 2018a, Helmberger et al., 2020).

Specifically, MPs have been shown to have a variety of toxic effects on humans and terrestrial insects especially termites (Segovia-Mendoza et al., 2020; Wright and Kelly, 2017; Wright et al., 2013). For example, termites can easily ingest MPs of any size, shape, and color once they are in an ecosystem (Bertoli et al., 2022; Grøsvik et al., 2022; Ribeiro et al., 2019). Once termites eat MPs it will negatively impact their ingestion, growth, reproduction, and behaviors (Cong et al., 2019; Franzellitti et al., 2019; Huang et al., 2020; Zhao et al., 2023; Zhu et al., 2023). MPs that are ingested by termites can affect their body by blocking digestive tracts, preventing the absorption of nutrients, and causing internal organ injuries. This can cause malnutrition, problems with reproduction, and reduced growth. In addition, when termites eat MPs that include persistent organic pollutants (POPs), heavy metals, and other harmful substances, they might be impacted by negative consequences including immunological suppression, endocrine system disruption, and heightened illness vulnerability.

# CHAPTER 3

# MATERIAL AND METHOD

## 3.1 Study Area


Figure 2: Kampung Bukit Jering, Jeli, Kelantan Google Earth Image.

The termite (Isoptera) sampling was conducted in Kampung Bukit Jering, situated in the Jeli district. The geographical coordinates of Kampung Bukit Jering are 5° 28' 31''N latitude and 101° 53' 47''E longitude. This location was chosen for its suitability for termite sampling due to its natural surroundings, which provide an optimal environment for termite populations. The village is characterized by diverse tree species and traditional wooden houses, both of which offer critical habitat and food resources for termites. Furthermore, Kampung Bukit Jering features a tropical rainforest climate, characterized by high humidity and stable temperatures year-round, creating ideal conditions for termite habitation and activity.

### 3.2 Materials

This study aims to determine the microplastics in termites using the following materials and equipment:

| No. | Purpose | Items |
|---|---|---|
| 1. | Sampling termites at Kampung Bukit Jering, Jeli, Kelantan | - Tools and container<br>- Analytical balance<br>- Forcep |
| 2. | Identification of microplastics on the external body part of termites | - Microscope<br>- Microscope slide<br>- Analytical balance<br>- Forcep<br>- Petri dish<br>- Aluminum foil |
| 3. | Hot needle test | - Petri dish<br>- Metal needle<br>- Bunsen burner |
| 4. | Digestion of microplastic | - Conical flask<br>- Aluminum foil<br>- Graduated cylinder<br>- Spatula<br>- Analytical balance<br>- Distilled water<br>- Hydrochloric acid<br>- Sodium chloride |

| | | |
|---|---|---|
| 5. | Filtering digestion | - Whatman Cellulose Acetate membrane filter paper<br>- Vacuum pump<br>- Tube<br>- Filtering flask |
| | | - Buchner funnel<br>- Petri dish<br>- Aluminum foil<br>- Forcep<br>- Distilled water<br>- Desiccator<br>- Drying oven |
| 6. | Microplastics determination | - Micro-FTIR (Micro-Fourier Transform Infrared Spectroscopy). |

Table 2: The materials and equipment were used to determine the microplastics in termites.

## 3.3 Methods

### 3.3.1 Termite sampling and preparation.

Termites (*Isoptera)* were collected from dead coconut trunks at Kampung Bukit Jering, Jeli, Kelantan. Termites are rarely found on the outer surface of coconut trunks because their nests are inside the trunks. Therefore, several tools such as axes and hammers were used to remove the bark and collect the sample of termites. The sampling of termites inside trees, especially trunks, was done carefully because it will destroy termites' habitat.

The sampling method that was used to find as many termites is hand-searching. Direct searching using the hand is the most successful sampling method to find a lot of scarce insect species under bark quickly (Siitonen & Martikainen 1994). Termites were instantly separated from the dead wood and were placed inside clean tools and containers (Tamashiro et al., 1973).

The total number of termite specimens collected was 30 grams and were separated into three replicates. Then, the samples that were collected were placed in Petri dishes and were put in a laboratory chiller (5℃-35℃).

a) b)

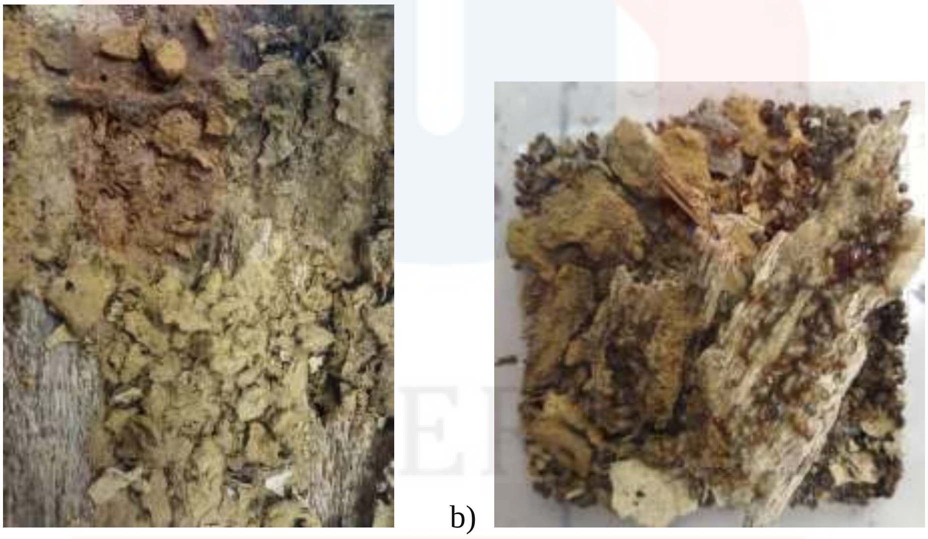


Figure 3: Termites live inside dead coconut trunks.

### 3.3.2 Identification of microplastics on the external body part of Termites.

The identification was done using a microscope to visually identify the particles of microplastics and also other particles at the external surface of the termite's bodies. The termites were put on slides and examined under a high-powered microscope. The presence of microplastic particles was observed attached to termites' external body parts. For example, the type of microplastics such as fibers were identified based on their size and shape. The microplastic particles found were placed in petri dishes and prepared for a hot needle test. Last but not least, termite specimens need to be separated from debris and rinsed using distilled water to remove external particles like soil and organic waste. After that, the sample was left to dry.

a) 

Figure 4: A microscope was used to identify microplastic particles in the external body of termites.

### 3.3.3 Hot needle test.

Hot needle tests need to be used to determine the presence of microplastics in termite samples. This test involved a heated needle to probe and identify microplastics, often discovered as fiber. Firstly, a metal needle is heated until it is sufficiently hot and closed into the microplastic pieces. Make sure the needle is hot enough and close to the pieces (Witte et al., 2012). Then, the reaction of these microplastic pieces to the heat was observed. For example, we might see if the pieces melt or curl, meaning that pieces contain microplastics (Witte et al., 2012). This is because plastics have melting points that are quite low and will react clearly to the heat that the needle applies.

### 3.3.4 Physical detection of microplastics on termites.

The termite samples were placed into three replicates of the digestion vessels which is a conical flask. Digestion methods (enzymatic or chemical) were used to break down organic material while preserving microplastics. Hydrochloric acid (HCl) is a useful chemical for chemical digestion. A suitable concentration of Hydrochloric acid (HCl) is 5 ml (30%) and 30 ml (4M) of sodium chloride (NaCl) is added to each sample. This concentration efficiently breaks down organic compounds without damaging most types of microplastics. It is because, at a concentration of 30%, the HCl would efficiently degrade organic molecules. Then, the NaCl, at 4M, would help to keep the solution's ionic strength stable, which would assist the separation process. Next, each replicate of the conicals flask was covered with aluminum foil. The samples should be put in the laboratory shaker to be shaken for 120 hours equivalent to 5 days (Akindele et al., 2020). These conical flasks were shaken in a shaker at 25°C for 120 hours to ensure thorough digestion of the organic materials.

Figure 5: Three replicates of the sample were shaken in a shaker.

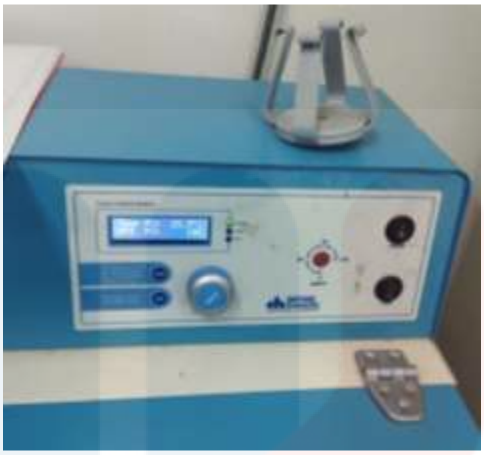


Figure 6: 25°C of temperature was set on the shaker to be shaken for 120 hours.

Figure 7: The sample after being shaken in the shaker for 120 hours.

**3.3.5 Filtration of Digestion.**

Whatman Cellulose Acetate membrane filter paper (0.2 µm pore size) was used to isolate the microplastics from the digested samples. The filter paper was placed on the base and was clamped on the funnel. A small volume of distilled water was added to the filter to wet it and seal it against the base. Pour the digested sample onto the membrane filter and turn on the vacuum pump to generate a pressure differential that will force the sample through the filter. Then, the filter was removed from the base carefully to avoid damage and was placed into a petri dish. After that, three replicates of filter paper were placed in the drying oven for 2 hours at 40°C-47°C. After 2 hours, these filter papers were taken out and cooled in a desiccator.

Figure 8: The filtration process to isolate the microplastics from the digested samples

a)  b) 

Figure 9: The filter papers were dried in the oven for 2 hours at 40°C-47°C.

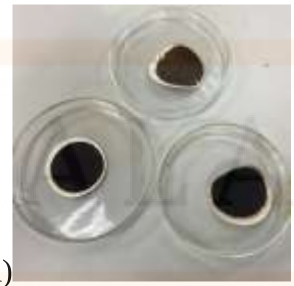
a)  b) 

Figure 10: The filter's condition after was taken out and cooled in a desiccator.

### 3.3.6 Determination of Microplastics.

Based on their chemical composition, microplastics can be effectively identified and categorized using Fourier Transform Infrared Spectroscopy (FTIR). The sophisticated NicoletTM iZ10 FTIR Spectrometer, intended for in-depth spectral investigation, was employed in this analysis. Dried filters with microplastic samples ready for the investigation were used for the examination. Attenuated total reflectance (ATR) mode was used for the measurement, specifically micro-ATR (μATR), which is appropriate for analyzing small, solid samples such as microplastics. This mode allows the microplastic sample that is positioned on top of the ATR crystal to transmit infrared light. A wide range of wavelengths (4000-500 cm^-1) are covered by the absorbance data collected by the NicoletTM iZ10 FTIR Spectrometer.

The resulting spectrum acts as the sample's molecular fingerprint, showing characteristic absorption peaks that correlate to different chemical bonds and functional groups found in the microplastics. A total of 32 co- added scans covering the 4000-500 cm^-1 wavelength range were carried out for the measurements, each with a spectral resolution of 4 cm^-1. OMNIC software was then used to analyze the acquired data.

# CHAPTER 4

## RESULTS AND DISCUSSION.

### 4.1 Results

| No. | Samples of Termites | Figures of Microplastics Under the Microscope. | Types of Microplastics |
|---|---|---|---|
| 1. | Sample 1 |  | Fibers |
| 2. | Sample 2 |  | Fibers |

| | | | |
|---|---|---|---|
| 3. | Sample 3 |  | Fibers |

Table 3: Types of Microplastics were detected under the microscope

A form of microplastic that was found in three samples under a microscope is displayed in Table 4.1.1. The diagram of microplastics under the microscope shows that the types of microplastics found in the three samples are fibers only. For example, most fibers are found in the head, legs, wings, and body of the termites.

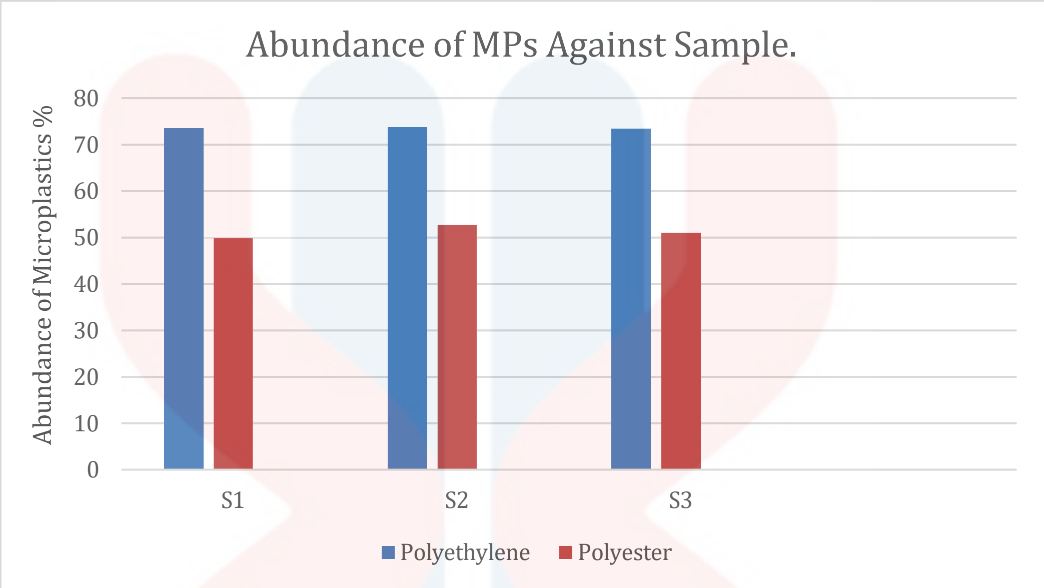



Figure 11: Abundance of MPs Against Sample.

Figure 4.1.2 shows the number of microplastics detected in the three termite samples S1, S2, and S3. The types of microplastic found in all three samples are the same, namely Polyethylene and Polyester.

| No. | Types of Microplastics | Sample 1 | Sample 2 | Sample 3 |
|---|---|---|---|---|
| 1. | Polyethylene | + | + | + |
| 2. | Polyester | + | + | + |

Table 4: The Presence of Microplastics, Namely Polyethylene, and Polyester in Sample 1, Sample 2, and Sample 3.

Table 4.1.3, indicates the presence of microplastics in all three samples. The names of microplastics found in all three samples are Polyethylene and Polyester.

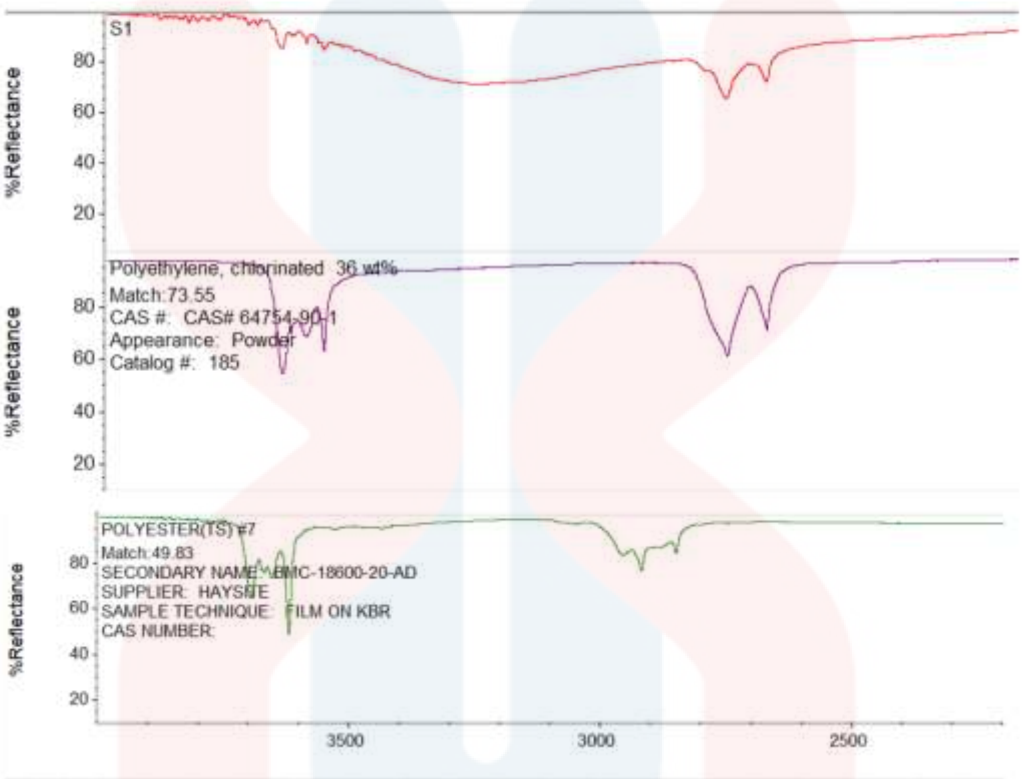



Figure 12: Types of Microplastics in Sample 1.

Figure 12 indicates 2 types of microplastics that been found in sample 1 which are polyethylene and polyester.

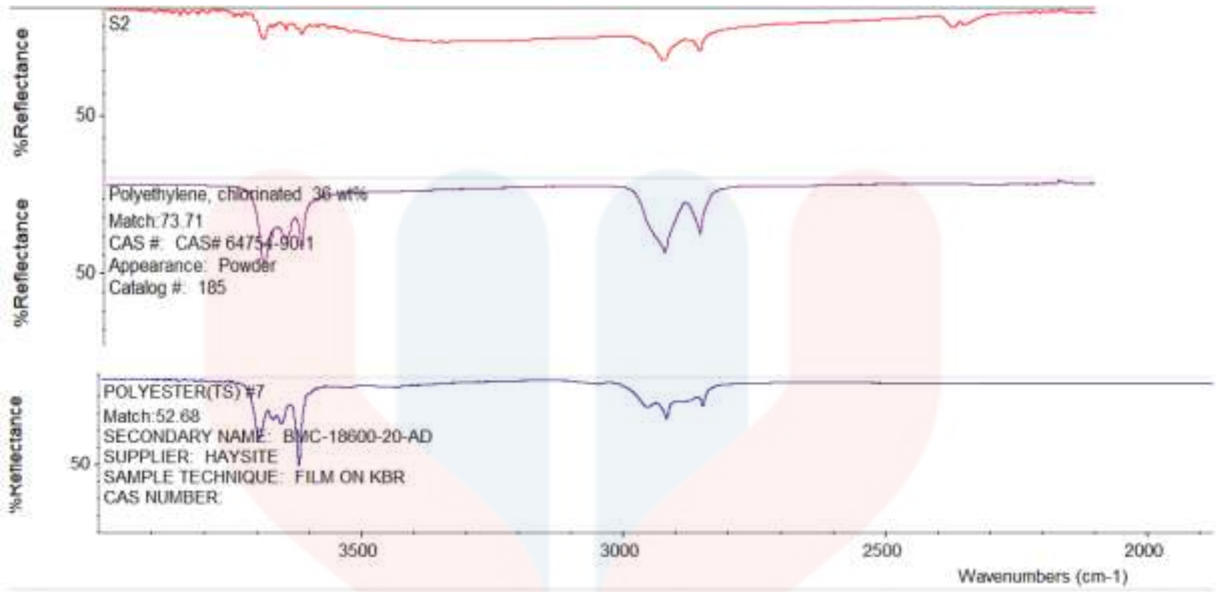



Figure 13: Types of Microplastics in Sample 2.

Figure 13 indicates 2 types of microplastics that been found in sample 2 which are polyethylene and polyester.

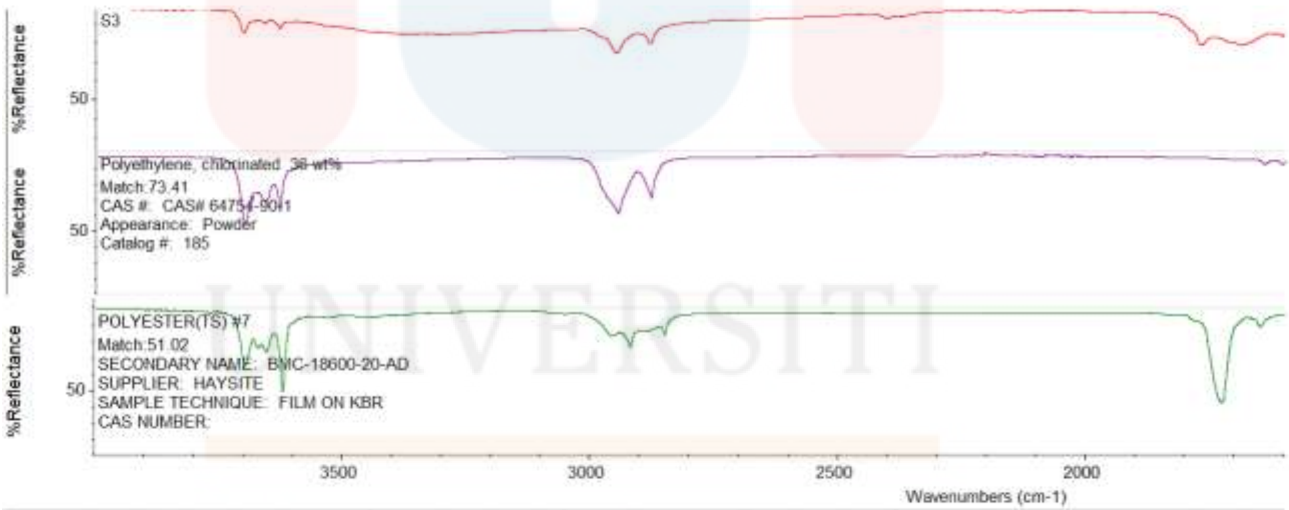



Figure 14: Types of Microplastics in Sample 3.

Figure 14 indicates 2 types of microplastics that been found in sample 3 which are polyethylene and polyester.

### 4.2 Discussion

The major types and categories of microplastics are five, the most common in the environment are fragments, fibers, foam, pellets, and film (Anderson et al. 2017). However, fibers are the only type of microplastics recorded in the three samples. Fiber was recorded in termites because termite samples were taken at the edge of the village's residential area. The fibers were detected under a microscope based on their size and shape. The size of fibers captured ranged from 0.5 mm to 5.0 mm in length. The total number of fibers that were recorded is 125. Fibers have been found in the external parts of the termite's body such as the head, legs, body, and wings. Fibers are frequently released into the environment by washing synthetic clothing, ropes, and nets. It has the potential to affect terrestrial insects like termites. Termites might ingest fibers while feeding and lead to cause internal obstructions and toxic effects. The frequency of fibers in the samples reveals that they are typical microplastics in soil environments.

Based on the bar graph (Figure 4.1.2), Polyethylene and polyester are the microplastics recorded in the sample using Fourier Transform Infrared Spectroscopy (FTIR). For example, all the samples which are S1, S2, and S3 are recorded with the same types of microplastics. Polyethylene is one of the primary types of microplastics in the polyester family and polyethylene is commonly used in synthetic fiber production of clothing, drinking water, and packaging materials (Neethu N, 2017). In sample 1, the results show that Polyethylene has the highest abundance recorded which is 73.55%, while polyester has recorded 49.83% of abundance. Then, in sample 2, polyethylene has also been stated to have the highest abundance which is 73.71%, and the abundance of polyester is 52.63%. Lastly, in sample 3, the abundance of polyethylene is higher than polyester. The result is recorded that polyethylene has an abundance of 49.83%, while the abundance of polyester is 51.02%. Overall, polyethylene was recorded as the highest abundance in three samples compared to polyester. The microplastics that are present will accumulate in the bodies of termites that eat wood or other organic materials in the soil that have been contaminated with microplastics. It will accumulate in the termite's body because these insects are unable to digest microplastics. The accumulation of a lot of microplastics in the termite's body will cause their life to be disrupted and can also cause death if the amount of microplastics in the termite's body is too high.

Table 4.1.2 shows the presence of microplastics in all the three samples. The results of this study show that there are two types of microplastics, namely polyethylene, and polyester, which were present in all three replicates of termite samples. The location of the termite samples is the reason why the same type of microplastic polyethylene and polyester was found in all three samples. Termite samples were taken in the residential areas. The presence of microplastics in the termite's body may be due to the use of plastic items daily. But despite that, the community does not realize that plastic is a 'silent' enemy to humans and can 'kill' them. For example, Polyethylene is often used in packaging such as plastic bags, plastic water bottles, and plastic food containers (Romani et al., 2020), polyethylene can be released into the air and the environment through unmanaged disposal of plastic waste. Then, polyester is the main material in clothes, and microplastics from this material can be released into the air and the environment through washing clothes. Polyethylene and polyester intake have been reported to be harmful to the health of insects (Balzani and associates, 2022, Ju and associates, 2019, Kim and An 2020).

Last but not least, The FTIR analysis results graph for sample 1 is shown in Figure 4.1.4. Sample 1 indicates two types of microplastics in sample 1 which are polyethylene and polyester. Figures 4.1.5 and 4.1.6 display the same types of microplastics in both samples. The presence of synthetic polymers in termites, such as polyethylene and polyester will affect the behavior of termites, fertility, and their growth will be slowed.

ATR-FTIR was used to characterize the microplastic sample in order to determine the polymer composition of each sample. The ATR-FTIR data revealed that Samples 1, 2, and 3 came from polyethylene and polyester (Figure 4.1.4 - Figure 4.1.6). Firstly, it shows polyethylene has significant peaks at the band around 3000- 2800 $cm^{-1}$ for C-H stretching. The absorption band for C-CI stretching was observed at 600-800 $cm^{-1}$. Meanwhile, polyester has significant peaks at the band around 1750-1700 $cm^{-1}$ for C=0 stretching. Then, the absorption band for C-O stretching was recorded around 1300-1000 $cm^{-1}$.

CHAPTER 5

# CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

In conclusion, this study aims to determine the occurrence of microplastics in termites and characterize microplastics in termites. The objective of this study was achieved because there is a record that the external body of termites has the presence of microplastic which is fibers. Then, based on Fourier Transform Infrared Spectroscopy (FTIR), it can be concluded that there are microplastics in all three samples, namely Polyethylene and Polyester. Based on the findings of this study, the presence of polyethylene in termites is higher than in polyester.

## 5.2 Recommendation

According to the results of this study, a few recommendations can be made to address the problem of microplastic pollution and its impact on the environment and public health. Firstly, the recommendations for the microplastics problem are public awareness and education campaigns. If people are aware of the negative impact of microplastics on the social, environmental, and economic effects of mismanaged single-use plastics, microplastic pollution will decrease (UNEP, 2018). Awareness and education campaigns on the negative impact of microplastics can be carried out through social media, newspapers, posters, and brochures. The content found in a variety of media can have a positive impact on society. Through the campaign, people will be taught about the importance of taking care of the environment, managing waste, and encouraging users to recycle recyclable materials.

The other recommendation is that people must support the adoption of environmentally friendly alternatives to solve microplastic pollution. People are encouraged to use environmentally friendly alternatives when shopping, for example, using cloth or paper bags instead of plastic bags. Then, the government needs to ensure that suitable sustainable alternatives are available before banning plastic bags or any single-use plastic (Nwafor and Walker, 2020). Poor people may suffer from the ban if there are no sufficiently affordable and durable alternatives to replace plastic bags.

Next, the recommendation for future research on microplastics in termites is to measure soil pH and soil moisture during sampling. This method helps provide valuable information for understanding the presence and effects of microplastics in termites. It also helps to do data analysis for this study which is Pearson correlation. For example, the relationship between soil conditions and the presence of microplastics recorded in termites can be identified through Pearson Correlation.

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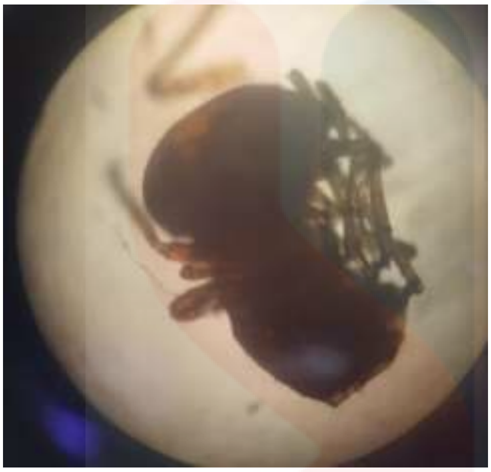
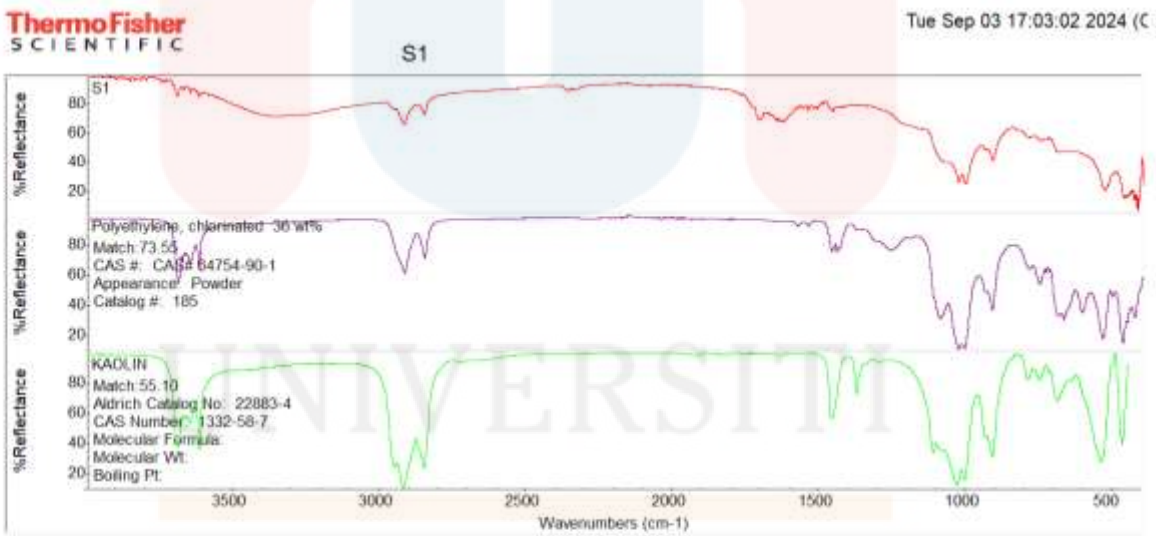
# APPENDIX

Fibers were detected under the microscope.



Fourier Transform Infrared Spectroscopy (FTIR) raw data of S1.




Number of sample scans: 16
Number of background scans: 16
Resolution: 4.000
Sample gain: 8.0
Optical velocity: 0.4747
Aperture: 150.00

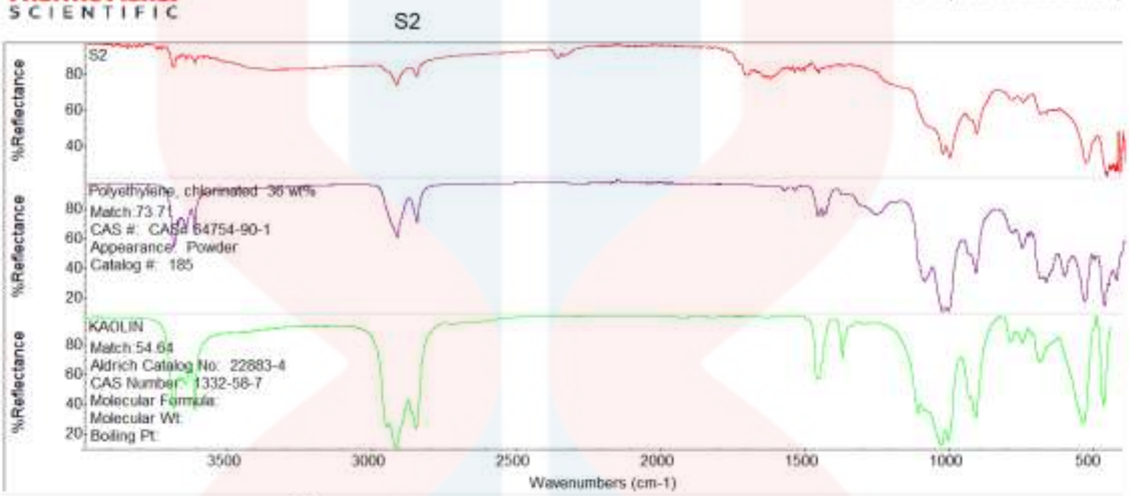
Spectrum: S1
Region: 3301.66-748.26
Search type: Correlation
Hit List

| Index | Match | Compound name | Library |
|---|---|---|---|
| 51 | 73.55 | Polyethylene, chlorinated 36 wt% | HR Specta Polymers and Plasticizers by ATR |
| 1519 | 55.10 | KAOLIN | HR Aldrich Organometallic, Inorganic, Silanes, Boranes, and Deuterated Compounds |
| 174 | 52.34 | FORMAMIDINESULFINIC ACID, 99% | HR Aldrich Phosphorous and Sulfur Compounds |
| 793 | 50.40 | Polyester with kaolin filler | HR Nicolet Sampler Library |
| 37 | 49.85 | BENTONITE (brown) | HR Specta IR Demo |
| 493 | 49.83 | POLYESTER(TS) #7 | HR Polymer Additives and Plasticizers |
| 8 | 49.05 | CELLOPHANE | Hummel Polymer Sample Library |
| 974 | 46.09 | ALUMINA SILICATE #2 | HR Polymer Additives and Plasticizers |
| 355 | 46.48 | (2-ENDO,3-EXO)-BICYCLO(2.2.2)OCT-5-ENE-2,3-DIMETHANOL, 96% | HR Aldrich Alcohols and Phenols |
| 1116 | 45.38 | N-ALKYL DIMETHYL ETHYL AMMONIUM ETHYL SULFATE MIXTURE | HR Polymer Additives and Plasticizers |

Fourier Transform Infrared Spectroscopy (FTIR) raw data of S2.

ThermoFisher SCIENTIFIC

Tue Sep 03 17:22:36 2024 (C

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Sample gain: 8.0
Optical velocity: 0.4747
Aperture: 150.00

Spectrum: S2
Region: 3301.66-748.26
Search type: Correlation
Hit List

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| 1519 | 54.64 | KAOLIN | HR Aldrich Organometallic, Inorganic, Silanes, Boranes, and Deuterated Compounds |
| 974 | 53.40 | ALUMINA SILICATE #2 | HR Polymer Additives and Plasticizers |
| 783 | 53.19 | Polyester with kaolin filler | HR Nicolet Sampler Library |
| 493 | 52.68 | POLYESTER(TS) #7 | HR Polymer Additives and Plasticizers |
| 37 | 52.13 | BENTONITE (brown) | HR Specta IR Demo |
| 973 | 46.84 | ALUMINA SILICATE #1 | HR Polymer Additives and Plasticizers |
| 8 | 46.78 | CELLOPHANE | Hummel Polymer Sample Library |
| 174 | 46.77 | FORMAMIDINESULFINIC ACID, 99% | HR Aldrich Phosphorous and Sulfur Compounds |
| 5 | 45.63 | 1,6-HEPTADIEN-4-OL, 97% | Aldrich Condensed Phase Sample Library |

Fourier Transform Infrared Spectroscopy (FTIR) raw data of S3.