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Ideonella sakaiensis and action de its depolymerizing enzymes of Polyethylene terephthalate (PET): a literature review

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Abstract: *Ideonella sakaiensis* is a gram-negative, aerobic, non-sporulated, rod-shaped bacterium isolated from a microbial intercropping collected in the city of Sakai, Japan, it has been identified that it degrades Polyethylene terephthalate (PET). The present work aims to present *Ideonella sakaiensis* and its important mechanism of action in the depolymerization of PET. This is a bibliographic review, by analysis of articles, journals, periodicals, websites and documents from studies between the years 2016 and 2021. The descriptors, *Ideonella sakaiensis*", "plastic/plastic" and "health/Heath" were used. Articles in English Portuguese and excluded any article that ran away from the theme. This bacterium demonstrates the ability to grow in PET and

has it as an energy source, enabling defragmentation through enzymes, which act depolymerizing the chemical structure of PET, characterizing an enzymatic bio catalysis process.

Keywords: Bacteria. Innovation. Plastic

1. Introduction

Ideonella sakaiensis is a gram-negative, aerobic, non-sporulated, rod-shaped bacterium that was isolated from a microbial intercropping collected in the city of Sakai, Japan, and is characterized on the basis of a polyphase taxonomic study identified that it degrades Polyethylene terephthalate (PET); (TANASUPAWAT *et al*, 2016). The bacterium demonstrates the ability to grow and transform PET into carbon and energy, from the production of two enzymes MHETase and PETase that break the polymeric structure of this plastic polyester.

Polyethylene terephthalate (PET) is the most abundant plastic polymer produced in the world. It is mostly in disposable packaging, beverage bottles and textile elements. It presents difficult recycling and low degradation capacity accumulating in the environment, which has been recognized as a large-scale environmental problem (WWF, 2019).

With the need to wrap and conserve products for sale, the choice of the most durable materials for use in the trade found no plastic, probably the most popular and adaptable material of this type of polymer (CORRÊA, 2019). PET was patented in the 1940s and it is possible that all the insum produced since that time has not yet been degraded (UNIVASF, 2019). In less than thirty years the World Wilde Found (2019) estimates that there will be more plastics than fish in the seas.

According to the Regional Council of Biomedicine (2nd Region), the competence of the biomedical professional inserted in microbiology is given by classifying, identifying and studying all aspects of microorganisms, in addition to developing technical-scientific research to evaluate how agents react to each other, com the environment in which they are inserted and affect each other living beings somehow. The way something affects a particular environment says a lot about how one should deal with its existence, whether it is by the increase in cases of disease or the excessive presence of plastic in the oceans, it concerns who wants a safe future.

The present work aims to present *Ideonella sakaiensis* and its important mechanism of action in the depolymerization of PET, which in some years may become a resource in the problem of plastic pollution, emphasizing that bio degradation Enzyme-mediated catalytic can potentially be integrated into the plastic recycling process to cooperate or replace current chemicals (ZHU, 2021). *Ideonella sakaiensis* stands out for its mechanism of synergistic action and possible use in relation to the problem, which makes it a promising strategy to reduce existing pollution.

2. Methodology

This is a systematic bibliographic review, by analysis of articles, periodicals, websites and documents from studies between 2016 and 2021. The methodology adopted focused on descriptive approach from electronic databases, i.e. Google Academic, PUBMED, SciELO and Science Direct in an attempt to find concepts, references, specific experiments and materials related to *Ideonella sakaiensis*, and plastic pollution.

The data presented were searched using the Descriptors and Boolean operators in Portuguese and in English, respectively: "*Ideonella sakaiensis*" E/AND "plástico/plastic", "*Ideonella sakaiensis*" E/And "Saúde/health". Refined then using the sentences "micro plástico/ microplastic" E/AND "Saúde/Heath", "Saúde/Heath" E/AND " ftalatos /phthalates.

The analysis was performed based on results and topics centered on the object of study. Articles that did not treat the use of *Ideonella sakaiensis* in PET degradation as the main theme were excluded

3. Results and Discussion

From the search performed, 31 publications were selected; PubMed databases, Google Scholar, SciELO and Science Direct. Eight studies were excluded according to the exclusion criteria. The twenty-three remaining articles met the inclusion criteria and were used to make the study as a scheme d'or in Table 1.

Table 1. Publications and databases used to make up this research

	SciELO	**Science direct**	**PubMed**	**Google academic**	**WWF**	**Total**
Selected	4	11	14	1	1	31
Deleted	1	5	2	0	0	8
Total	**3**	**6**	**12**	**1**	**1**	**23**

Source: Author's elaboration.

Ideonella sakaiensis

Tanasupawat *et al*. (2016), the bacterium grew at variable pH of 5.5 - 9.0 and temperature between 30° - 37° Celsius. The species *Ideonella dechloratans* and *Ideonella azotifigens* present different physiological and biochemical characteristics. The bacterium (figure 1) is a bacillus with a polar scourge, which enables its movement, capable of transforming organic carbon taken from the medium as its source of vital energy. (TANASUPAWAT *et al*., 2016).

According to SEO (2019), studies on PETase, an enzyme secreted by *Ideonella sakaiensis*, indicate that the

mechanism of action of the enzyme is unique, having greater activity in PET films than other hydrolases/esterases, capable of breaking down extremely large and hydrophobic polymer chains.

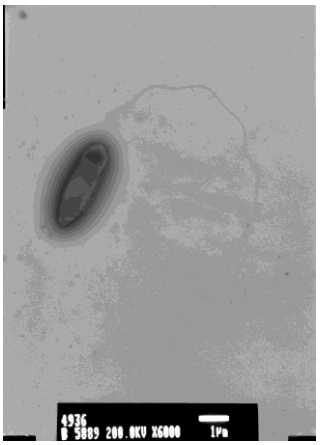

Figure 1. Electronic micrograph of *Ideonella sakaiensis*.
Source: TANASUPAWAT, *et al*. (2016).

The mechanism of action of *Ideonella sakaiensis* consists of depolymerizing carbon chains by means of two enzymes, PET hydrolase and MHET hydrolase. The bacterium demonstrates the ability to grow in PET and has it as an energy source, enabling defragmentation through enzymes, which act by depolymerizing the chemical structure of polyethylene terethalate (PET), characterizing an enzymatic bio catalysis process. (YOSHIDA *et al*., 2016).

PET degradation

PET is a thermoplastic resin formed by the reaction of two molecules, the tereftalic acid and ethylene Glycol which are characterized as a practically insoluble hydrocarbon has a functional group of testers in its main chain. According to Corrêa (2019), the use of thermoplastics is almost entirely in primary food packaging, however, the greatest application of thermosets is in the manufacture and preparation of paints, varnishes, sealants, adhesives, rigid systems for flexible packaging (caps, dosing systems, etc.), among others.

There are different bacteria, fungi and enzymes that are in evidence in the study of depolymerization of plastics, but degrading Polyethylene terephthalate (PET) are outnumbered compared to other polymers, some of these degrading are Streptomyces scables, Streptomyces sp. and Pseudomonas that release enzymes capable of breaking complex chains that are components of this material (AMOBONYE, 2021; SHARMA; JAIN, 2020).

Amobonye *et al* (2021) commented that the biotic component of synthetic plastic degradation is mainly attributed to the action of various microbial communities, which have been observed as potential xenobiotic degrading factors, such as PET; and is based on its ability to adapt and use these chemicals as their growth and energy substrates.

Zhu (2021), further states that by the omnipresence of plastics in different ecosystems and the tremendous metabolic diversity, there is the possibility that microbian communities in various habitats have probably evolved acquiring plastic decomposition capabilities. The process is being studied and tested to reduce the plastic pollution already existing on the planet.

Pollution by micro and nano plastics

Corrêa (2019), stated that among the raw materials that are most used in the cosmetics and food industries, the ones that stand out most in the garbage produced daily by the inhabitants in Brazil, are plastic and paper, making it necessary to evaluate the use of these two materials. Azeredo (2017) indicated that although the origin of the micro plastic is uncertain, reinforces the fact that when ingested by fish, they derive from larger materials that were degraded until they reach the environment where they were deposited.

For Kumar (2020), marine food it can be modified by the high concentration of micro and nano plastics, once accumulated the toxic chemicals present cause serious problems to aquatic life forms, such as mortality, internal and external physical damage, among other things.

According to Azeredo (2017), he informed that when found in large quantities, plastic micros can harm the health of fish, for example, through the accumulation of heavy metals and the loss of satiety. In addition to being responsible for causing negative physical effects in fish by preventing the absorption of nutrients due to their accumulation in food appendages and causing damage to gastrointestinal tissues, in addition to physiological effects that cause behavioral changes.

4. Conclusions

Ideonella sakaiensis can become a resource capable of depolymerizing an abundant plastic that is infiltrating all ecosystems on the planet. Its unique mechanism of action stands out because it addresses an accumulation of useless material and makes plausible the battle against a problem that affects many people. The release of toxic agents by plastic micros is a subject that has taken on great proportions, since environmental awareness is increasingly aligning with innovation.

Until there is a process of using microorganisms capable of affecting the accumulation of plastic pollution on the planet, many studies should be idealized, many habits changed, many discussions should be made and in-depth studies. For, the way in which the problem in question is dealt with creates more questions, which can be answered with further analysis and incentive to the growth of environmental and scientific responsibility of those who inhabit the planet.

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To God for his infinite mercy.

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