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Review of the dissertation thesis "Investigating the influence of different additives on the mechanical properties and biodegradation of PHB and PBS" by Ahmad Fayyaz Bakhsh

The work focuses on biodegradable polymers and their blends with various natural compounds, which are intended to modify their biodegradation dynamics and mechanical properties. The main polymers investigated in the thesis are polyhydroxybutyrate (PHB) and polybutylene succinate (PBS). The topic is timely, as the use and production of biodegradable polymers are on the rise, with the aim of eventually replacing fossil-fuel-based polymers.

The thesis consists of 100 pages, including a list of references, abbreviations, and a résumé. The author begins with an introduction to the topic, followed by a discussion of the challenges, modifications, and the aim of the work. This is followed by the theoretical part, experimental part (which includes descriptions of some analytical techniques), results and discussion, and conclusions.

From a formal point of view, the work leaves much to be desired. I will mention only the most critical issues, as the work contains numerous imperfections. The layout is problematic, with the author frequently repeating information. For example, page 15 repeats content on biodegradation and its products that was already presented on page 7. The experimental part is especially problematic, as it lacks critical details. For instance, there is no mention of which soil type was used for biodegradation tests, how samples were measured in the burial test, which detectors were used in SEM analysis, how and why plasma treatment was conducted, or details of the crosslinking procedures. As a reader, it was challenging to get a clear understanding of the experiments and their purpose in the study.

In the results and discussion section, most of the text is dedicated to the description of results, with little effort to explain or interpret them. At times, the author refers to data that is not presented in the thesis. For example, on pages 40-41, it states that "Figure 12 shows... green tangerine blend, exhibiting a degradation pattern similar to pure PHB but with a slightly faster initial rate." However, Figure 12 only shows pictures of the "physical shapes of PHB and PHB blended with plant oils," and no degradation rate can be inferred from this Figure. Similarly, on page 49, the author claims that "As can be seen in Fig. 17, the samples began to degrade by microorganisms from the amorphous part, while the crystalline parts remained." It is unclear how this conclusion can be drawn from the dependence of mineralization on the duration of biodegradation as shown in Fig. 17.

There are also inconsistencies in the presentation of data. For example, in Figure 27, the data are fitted with a curve, whereas in Figure 29, for a similar dataset, the points are simply connected. In Figure 13, only lines are shown, with no data points. Also, the author attempts to follow biodegradation based on SEM images taken on the 4th and 32nd days, but a reference image (i.e., the surface before the experiment) is missing.

Lastly, in section 5.3 on collaborative studies, the author mentions that "the experiment was performed with a group of researchers at a private company on some confidential products...". This raises the question of whether confidential research should be included in a dissertation, as it prevents the reviewer from assessing the validity of the conclusions. Moreover, some diagrams, such as the one in Figure 16, are overly simplistic and lack the depth expected in a dissertation thesis. Additionally, the English requires improvement, as certain expressions (e.g., "meticulously") are overused.

Overall, the impression from the thesis is not positive - it is chaotic, poorly done and immature.

Furthermore, it is unclear whether the entire thesis or parts of it have already been published. The author lists four publications in his CV, which appear to be related to the subject. In one of them, Ahmad Fayyaz Bakhsh is listed as the lead author, but his specific contribution remains unclear.

Therefore, after considerable hesitation, I recommend the thesis for defense. However, I suggest awarding the Ph.D. degree only after the successful completion of the questions attached to this report.

Questions:

1. Can the student explain why it would be beneficial to prevent or stabilize biodegradable polymers against rapid biodegradation? Both PBS and PHB are very expensive to produce compared to conventional plastics, and they are developed primarily for their biodegradability, which is their only viable disposal method. On page 77, it is stated that "by incorporating these additives, we can reduce the frequency of mulch replacement, leading to cost savings and less environmental disruption." Are there other effective ways to dispose of biopolymer waste?
2. Which kind of PHB was used in the tests? What was its origin? Are there any possible negative impacts of biopolymers such as PHB on soil ecosystem functions?
3. In Figure 32 occurs a decrease in mineralization during the degradation processes after 200 days, what is the reason? Sometimes, the mineralization in soil is 100%, is this possible?
4. In Figure 32, there is a decrease in mineralization during the degradation process after 200 days. What is the reason for this? Is it possible for mineralization in soil to reach around 100%?

5. Why did you measure the degree of crystallinity and the glass transition? Are these parameters not interrelated?
6. On page 64, the author claims that the PLA/PHB blend completely degraded under home composting conditions. This conclusion was based on the observation of residues, but was the potential formation of microplastics also considered?
7. Table 3 reports the crystallinity of PHB and its blends. How were these values determined, and what is the measurement error? What is the explanation for the decrease in crystallinity during biodegradation for pure PHB and its blends? The explanation provided on pages 49-50 is confusing.

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