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BIOGEARS

Biobased gears as solutions for creation of an eco-friendly offshore aquaculture sector, in a multitrophic approach, and new biobased value chains

Deliverable 3.3

Design and development of prototypes of biobased aquaculture ropes at lab scale and prototype manufacturing at pre-industrial scale.

WP 3 Design and development of biobased rope prototypes (TRL 4**).**
Deliverable 3.3
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Summary

With the achievement of this milestone for the project, the production of rope prototypes BIOGEARS targets the technical approach of the obtaining biogears, biobased and biodegradable ropes for marine aquaculture and the generation of BLUE LABs. The main technical achievements of WP3 are included in the scope of this deliverable and are summarised as follows:

- Selection of the bio-based material candidates based on commercially available natural yarns used in other sectors of applications (wear, water absorbers) and specially on the formulation of new biodegradable compounds for fibres production that consider functionality and biodegradation requirements. Bioplastics candidates, and a third group of bio-based materials, based on the combination of bioplastics and naturals fibres has been considered in order to minimise the risk of non-acceptability of mussel and seaweed culture.
- Adapt the materials selected in the previous activity terms of processability (extrusion melt spinning to produce multifilaments /yarns) as intermediate step required for the development on new ropes prototypes for validation in mussels and seaweed aquaculture. The development of the new bio-based multifilaments may require the reformulation of the bio-based compounds with processing additives. The characterisation of the developed yarns will establish the Pass/non-pass criteria for the next prototyping stage.
- New designs of bio-based ropes considering new materials properties and the functionality requirements for aquaculture, such as, to increase the surface area for mussels and seaweed adhesion. The result of this activity has produced at least 3 bio-based ropes prototypes for validation in aquaculture facilities.
- The prototypes will be validated in terms of evaluation the productivity yield for mussels and algae. Current oil-derived plastic ropes currently in the market will be used as counterpart for comparison.

Contents

1. Objective

The objective if this deliverable is related to Objective 3 of the BIOGEARS proposal:

> **O3:** To provide biobased aquaculture rope prototypes with TRL 4; by selection and characterize bio-based materials with to produce textile yarns, and the manufacturing of rope prototypes at pre-industrial scale.

Within Task 3.3, ITSAKORDA has design and produce the biobased rope prototypes in the quantity required to be tested in WP4. The designs have considered different configurations as the inclusion of additional internal or external loops to increase the surface area and the mechanical properties. The workflow of this activity has been: (1) GAIKER: to produce the bioplastic compounds in scale of 50-80 Kg (option 2) 04 and 07 at pilot scale; (2) CENTEXBEL to produce and characterise the multifilament's according to defined specification in quantity of 50-80 Kg and (3) ITSASKORDA to produce the ropes (at least 120m/prototype) by combining the following processing sequence: Twisting of yarns, Inverse stranding, and Closing. The parameters of the equipment will be adjusted to the new bio-based materials (including conditioning operations of the new yarns/multifilament and any auxiliary material required) to obtain the required quantities for testing and monitoring in WP4. Additionally, prototypes with commercial materials (PE/PP) and using commercial designs have been also manufactured to be used as counterparts for comparison purposes in WP4 and in Task 5.1 of WP5.

2. Background

Composition of compounds BIOGEARS 04 and BIOGEAES 07 and characterisation of monofilaments obtained are detailed in Deliverable 3.1. and Deliverable 3.2 respectively. Information of both deliverables is confidential.

3. Methodology

To develop the right bioplastic formulation for the aquaculture sector, it is important to balance the functionality and biodegradation behaviour of the biobased ropes and a number of research activities have been conducted into the design and development of the biogears prototype.

In order to identify the target properties for the biogears, the technical and functional specification for plastic ropes currently used in aquaculture were defined. The final specification was selected after considering the rope characteristics, durability, surface area and rope structure, and cost-efficiency in mussel and seaweed culture. Potentially suitable biobased materials were selected and characterised for fulfilment of mechanical (strength and elongation) linear density. Filament extrusion tests were performed at lab scale in order to select/discard the commercially available grades suitable for production of fibre/yarns. From this, biobased monofilaments were developed and technically assessed in terms of mechanical and rheological properties (complex viscosity). Once suitable materials were selected, the prototype development considered different configurations such as the inclusion of additional internal or external loops to increase the surface area and the mechanical properties most suitable for mussel and seaweed production.

The next step in the project is to test the prototype in field trials for validation at sea to reach TRL 5 – 7 in WP4. Test facilities have been identified in different sea environments: 1. offshore high energy conditions in a longline system, 2. low energy conditions in a raft system, and lastly 3. an Integrated Multi-Trophic Aquaculture (IMTA) proof of concept at lab scale in a research centre. The field demonstrations are set up and will perform and monitor at least two production cycles with biobased ropes under best practices for eco-friendly aquaculture.

These prototype biogears and pilot tests taking place in the BIOGEARS project aim to reduce the current technological gaps of biobased and biodegradable ropes for use in aquaculture and extend the potential use in the sector through Europe. The results of the project support creating a new biobased value chain under the EU Bioeconomy Strategy framework.

3.1 Production of compounds

The selected compounds ans tenacities obtained at lab scale are:

- Biogears 04. Tenacity: 2,80-3,47g/de
- Biogears 07. Tenacity 3,74g/De

The compounds have been processed in the Leistritz extruder from Gaiker.

Figure 1. *Leistritz extruder from Gaiker.*

1) 52 Kg of Biogears 04 is prepared according to the following processing parameters:

    a. Predrying. Components are predried overninght at 50-55 ºC and 100º during 3 h prior to processing.

    b. The compound has been fed into the extruder in the main feeding point and the melt filament has come out from a nozzle with double filament hole. The melt filament has come out along a water bath and air-drying pulling cart.

c. The temperature processing conditions have been established considering composition up to 180ºC and 195º (die zone).

d. Production rate 4 Kg /h.

Figure 2. *Two melted filaments coming out of the nozzle.*

Figure 3. *Detail of the monofilament during production of (Biogears 04) pellet.*

The 52 Kg of compound BIOGEARS 04 was shipped to CENTEXBEL for multifilaments production. A sample of 300g of the compound processed is saved at GAIKER for characterization purposes.

2) 57 Kg of Biogears 07 is prepared by twin screw extrusion according to the following parameters

a. Predrying. Components are predried according to suppliers' recommendations.

b. The compound has been fed into the extruder in the main feeding point and the melt filament has come out from a nozzle with double filament hole. The melt filament has come out along a water bath and air-drying pulling cart.

c. The temperature processing conditions have been established considering composition from 175ºC up to 180ºC and 195º (die zones).

d. Monofilaments die has been used

e. Production rate 5 Kg /h.

Figure 4 *Biogears 07) filament under the water bath.*

The 52 Kg of compound BIOGERAS 07 was shipped to CENTEXBEL for multifilaments production. A sample of 300g of the compound processed is saved at GAIKER for characterization purposes.

3.2 Production of multifilaments

The BIOGEARS compounds supplied by GAIKER were processed on the multifilament extrusion line of CENTEXBEL (presented in the figure below). Multifilament production is based on air-cooling of the melt after which the yarn is stretched over different heated godets.

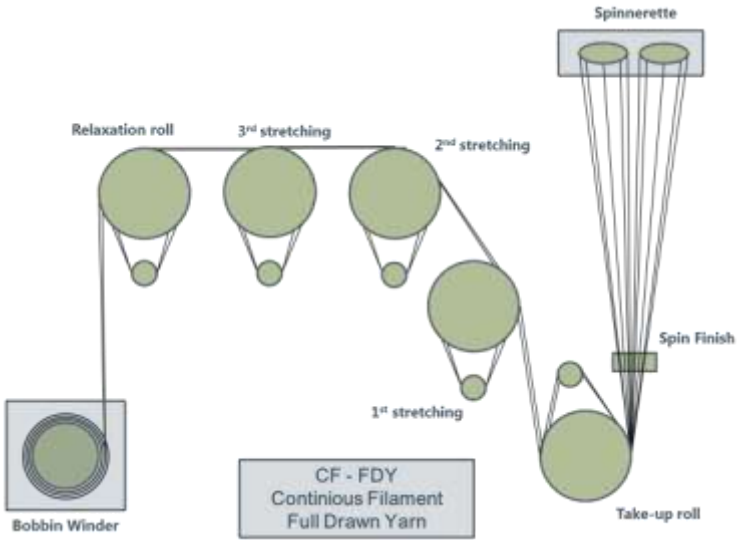


Figure 5 *Multifilament production scheme at CENTEXBEL.*

Yarns of 600 dtex were produced following the standard processing conditions as listed in the table below.

Spinneret	**60 round**
Temperature extruder (°C)	230°C
Throughput	8 kg/h
Yarn fineness	10 dpf (dtex per filament)
Cold draw ratio	3 - 5x

Project partner Gaiker supplied 2 compounds, which were already tested on the monofilament extrusion line and were now processed at larger scale on the multifilament extrusion line.

The first compound (compound04) was well processable and 40 kg of yarns could be produced. The second compound (compound07) showed more difficulties. Only after diluting with neat PLA, the compound could be processed, yet at a lower draw ratio. 34 kg of yarn was produced with this compound.

The mechanical properties of the yarns were determined following the standard EN ISO 2062 (2009). The results are summarized in the table below. As can be seen, lower tenacities were obtained with the second compound, due to the lower draw ratio and the more difficult processing.

	Tenacity (cN/tex)	**Elongation (%)**
Compound04	30 ± 1	33 ± 1
Compound07	19 ± 1	32 ± 4

3.3 Production of ropes

The multifilament obtained at CENTEXBEL were shipped to ITSASKORDA in bobbins for the manufacturing of prototype ropes at semi-industrial scale (Figure 6), using rope manufacturing industrial machines, following processing specifications of commercial rope counterparts (Figure 7).

4. Results & Discussion

4.1. Rope prototype

After processing two types of rope prototypes, coming from 04 and 07 biobased compounds, around 80 m of each prototype type were obtained.

Figure 7 *Sequence of the rope prototype production, using multifilament bobbins (A) at industrial rope manufacturinf machine at Itsaskorda's (B), to obtain rope with characteristics of commercial counterparts (C) and finally cut down to the length for mussel suspended culture (D).*

Some more multifilament bobbins were kept producing seaweed rope prototypes with different functional and mechanical characteristics from rope prototypes manufactured to be used for mussel suspended culture (either in longline or in raft).

The obtained rope prototypes were produced following the manufacturing process specifications of commercial counterparts, GROPE type ropes (Figure 8). These ropes are twisted and looped (can be produced with different loops) and are used as growing out rope with extra attachment in longline systems (Long line simple & continuous) and are characterised to be floating ropes.

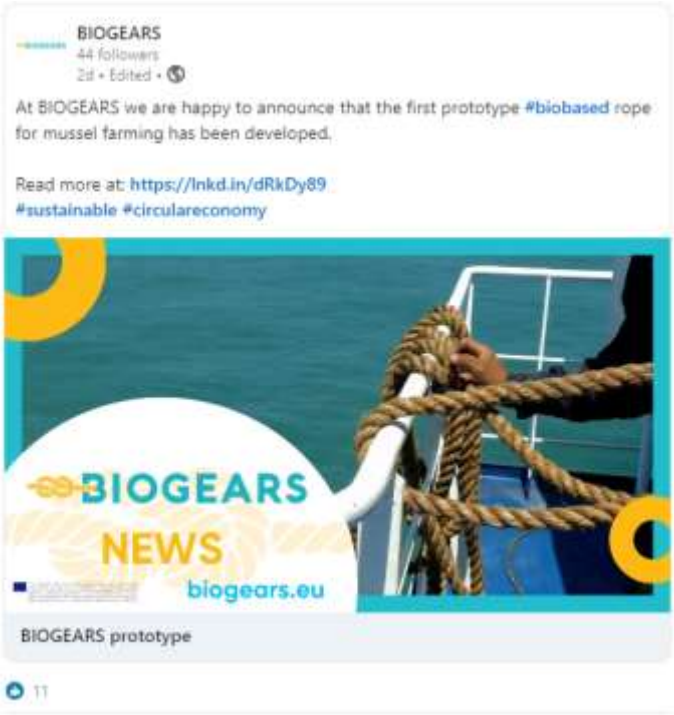
Figure 8 *Commercial rope counterpart (GROPE)*[1]

4.2. Dissemination Activities.

To share promote this key achievement of the project a number of dissemination and communication activities were carried out. Firstly, a press release (Annex 1) was created and distributed across partners networks, uploaded to CORDIS and shared through relevant media channels. A news article was published on the project website (https://biogears.eu/biogears-first-biobased-and-biodegradable-ropes-prototypes-now-ready/) and it was shared on the BIOGEARS Twitter and LinkedIn pages for widespread dissemination and promotion.

https://twitter.com/BIOGEARS_EU/status/1374333230464253952

[1] https://www.itsaskorda.es/wp-content/uploads/pdf/acuicultura-cabo-cultivo-en.pdf



https://www.linkedin.com/feed/update/urn:li:activity:6780101101640269824

5. Conclusion

The prototype ropes have been successfully produced, after a process of compounding at GAIKER lab scale facilities, yarn, and multifilament processing at CENTEXBEL experimental facilities, and finally processing to rope at ITSASKORDA at semi-industrial scale, with mechanical and functional characteristics of their commercial counterparts.

Finally, the functional validation at aquaculture facilities, and the sustainability of the new bio-based ropes will be evaluated in terms of technical degradation of mechanical properties during the monitoring period, and the economic and environmental impact of the whole bio-based system. As result of the BIOGEAR project, data of the performance/durability of bio-based material for aquaculture and their biodegradation behaviour at sea and in composting environments will be provided as well as their potential of use for other marine applications. The use of the new knowledge and results generated will be evaluated for transfer to other locations and marine application involving the use of textile.

6. Annex 1 – Press release

EU project develops biobased and biodegradable ropes prototypes for offshore aquaculture.

The EU-funded BIOGEARS project has developed its first biobased and biodegradable rope prototypes for offshore aquaculture. **The prototypes are a significant step towards the project's contribution to a more eco-friendly aquaculture industry.**

BIOGEARS aims to provide the European aquaculture sector with innovative products and a value chain to challenge the existing gap of biobased ropes (biogears) for offshore aquaculture, which are currently manufactured with 100% non-biodegradable (petrol-based) plastics.

The next step is to test the prototype in field trials for validation at sea. Test facilities have been identified in different sea environments, including offshore high energy conditions in a longline system; low energy conditions in a raft system; and an Integrated Multi-Trophic Aquaculture (IMTA) system. Once started, the field demonstrations will test and monitor at least two production cycles with biobased ropes under best practices for eco-friendly aquaculture.

These prototype biogears and pilot tests taking place in the BIOGEARS project aim to reduce the current technological gaps and extend the potential use of sustainable materials in the sector. The results of the project support creating a biobased value chain under the EU Bioeconomy Strategy framework.

To read more about the prototype development please visit: biogears.eu, Twitter, LinkedIn or subscribe to news

Or contact us: Project Coordinator Leire Arantzamendi (larantzamendi@azti.es) or Communication Contact Jane Maher (jane@erinn.eu).

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***Caption**: BIOGEARS prototype rope in production in ITSASKORDA, Biscay, Spain*

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