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ISSN: 2329-6798
Modern Chemistry & Applications

Commentary

Approaches for the Conventional Chitin Extraction from Crustaceans

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DESCRIPTION

The ecologically sustainable materials from the agricultural and food processing will soon become one of the most exciting challenges. Chitin and chitosan are two notable examples of how high value-added molecules can be extracted from food waste such as crustacean and fungal shells. Chitin exists in nature as ordered crystalline micro fibrils. X-ray diffraction and solid-state NMR spectroscopy revealed two main crystalline forms, α and β. Alpha structure is the most common and stable form. It is found in fungal cell walls, shrimp cells, and insect cuticles. The chains of α-chitin are arranged in antiparallel chains that are responsible for the characteristic elasticity of insect and crustacean exoskeletons.

Less stable and rare β structures are found in squid stye, spines and annelids. The warp threads stretch well and the softness increases.

Finally, ɣ-chitin, another known allomorph, is probably just a variant of α structure. In its stable state, chitin is a white or pale pink, tasteless and odorless solid. Strong intramolecular and intermolecular hydrogen bonds make chitin highly cohesive and insoluble in common solvents such as water, organic solvents, and weakly acidic or basic solutions. This drawback is a major limitation for many applications. Conversely, it can be solubilized in highly polar solvents such as hexafluoroisopropyl alcohol, hexafluoroacetone, lithium thiocyanate, and dimethylacetamide.

Many of these solvents are toxic or mutagenic, so finding safer alternatives is important for this area of research. An example of a good eco-friendly alternative method for dissolving chitin is described in the chitin dissolving method patent. The protocol prescribes the use of a mixture of NaOH and carbamide in which chitin is retained for 10 hours. After freezing at -18°C to -10°C for 7 days, the solution is stirred at room temperature. A major advantage of this method is that the waste liquid can be reused more frequently by reducing toxic by-products, but the long dissolution time required remains an unresolved problem.

Extraction from crustaceans is the most common process, and he has two methods: biological and chemical processes. Both involve two basic steps: desalting and deproteinizing.

In the biological method, desalting occurs by lactic acid produced by lactic acid bacteria. Lactic acid reacts with calcium carbonate in the crustacean exoskeleton, inducing the formation of calcium lactate. Calcium lactate precipitates and can be removed. Additionally, lactic acid creates the low pH needed to activate proteases present in bio-waste. Therefore, chemical methods are still the most widely used.

A chemical process consists of various steps. First, the powdered raw material is treated with an acid solution for up to 48 hours. The purpose is to remove the mineral component of the exoskeleton. Alkaline treatment is then performed to achieve deproteinization of the desalted husk. Proteins are removed with NaOH to produce chitin. An additional decolorization step can be performed if a colorless product is desired. Acetone, 10% H_2O_2 solution or organic solvent mixtures are used for pigment removal. All these steps can be performed sequentially by inserting a freshwater wash step to achieve neutralization. Unfortunately, these cleaning steps require enormous amounts of water, further limiting the sustainability of the overall process.

Fungi may be a viable alternative source of chitin. Unlike crustaceans, no desalting step is required. The starting material is mycelial biomass, which after a washing step can be homogenized in a standard kitchen mixer and immediately subjected to deproteinization.

This procedure is the same as previously described for crustaceans and can be performed with NaOH.

This route is an alternative to crustacean chemistry with several advantages as the fungus is not subject to seasonal or regional variations. Furthermore, fungi do not require HCl treatment, which crustaceans require to achieve desalting. Pure chitin can be obtained from the chitin-β-glucan complex by introducing an acid treatment to degrade the glucans, but this defeats one of the main advantages of mushroom extraction.

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Received: 27-Jan-2023, Manuscript No. MCA-23-20143; **Editor assigned**: 30-Jan-2023, PreQC No. MCA-23-20143 (PQ); **Reviewed:** 13-Feb-2023, QC No. MCA-23-20143; **Revised:** 20-Feb-2023, Manuscript No. MCA-23-20143 (R); **Published:** 28-Feb-2023, DOI: 10.35248/2329-6798.23.11.394

Citation: Peter M (2023) Approaches for the Conventional Chitin Extraction from Crustaceans. Modern Chem Appl.11:394.

The main limitations of the described conventional extraction protocols, the use of strong acid or alkaline solutions, the use of large amounts of water in the neutralization step between acid and alkaline treatments, and the long time. In recent years, the need to find effective eco-friendly alternatives for chitin extraction and adopt circular economy approaches has become an imperative challenge.