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ПРИМЕНЕНИЕ ПРИРОДНЫХ ГЛУБОКИХ ЭВТЕКТИЧЕСКИХ РАСТВОРИТЕЛЕЙ ДЛЯ ЭКСТРАКЦИИ МАКРОВОДОРОСЛЕЙ В РАМКАХ ОБЕСПЕЧЕНИЯ КОНЦЕПЦИИ УСТОЙЧИВОГО РАЗВИТИЯ

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Аннотация. Обсуждено, как соответствие целям устойчивого развития может способствовать повышению устойчивости экономики, в основном через «зеленую» и «синюю» экономику, которая включает валоризацию макроводорослей при получении экстрактов. Основное внимание уделено потенциалу эвтектических растворителей (deep eutectic solvents, DES). Классические методы экстракции биологически активных веществ (БАВ) из макроводорослей, основанные на использовании органических растворителей и буферных растворов, часто предполагают жесткие условия и длительный процесс, негативно влияющие на экологическую обстановку. Эти факторы могут привести к снижению качества экстракта за счет остаточных растворителей, большому углеродному следу за счет выбросов CO₂. При правильном выборе компонентов DES представляет собой «зеленую» и устойчивую альтернативу. DES обладают такими преимуществами, как низкая летучесть, регулируемая полярность и незначительная токсичность, что делает их более экологически чистым и эффективным вариантом для экстракции БАВ. Их можно настраивать для улучшения как биологических, так и технологических свойств, что приводит к получению экстрактов с уникальными характеристиками, такими как высокая антиоксидантная активность, антипролиферативное и противовоспалительное действие, а также улучшение физико-химических свойств БАВ из макроводорослей. Настраиваемый дизайн DES позволяет оптимизировать условия экстракции для увеличения выхода, чистоты и биологической активности экстрактов, что делает DES экологичной альтернативой для производства биопрепаратов и других продуктов. Рассмотрен потенциал DES и изложены основные преимущества и пути решения проблем при валоризации переработки макроводорослей.

Ключевые слова: «синяя» экономика, «зеленая» химия, рациональное природопользование, возобновляемые ресурсы, экстракция, глубокие эвтектические растворители, DES.

APPLICATION OF NATURAL DEEP EUTECTIC SOLVENTS FOR EXTRACTION OF MACROALGAE IN THE FRAMEWORK OF ENSURING THE CONCEPT OF SUSTAINABLE DEVELOPMENT

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Abstract. This article discusses how alignment with the Sustainable Development Goals (SDGs) can contribute to a more sustainable economy, mainly through the green and blue economy, which includes the valorization of macroalgae in extract production. The main focus is on the potential of deep eutectic solvents (DES). Classical methods for the extraction of biologically active substances from macroalgae, based on the use of organic solvents and buffer solutions, often involve harsh conditions and a lengthy process that

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negatively impact the environment. These factors can lead to a decrease in the quality of the extract due to residual solvents, a large carbon footprint due to CO₂ emissions. With the right choice of components, DES represents a green and sustainable alternative. DES have advantages such as low volatility, adjustable polarity and low toxicity, which makes them a more environmentally friendly and effective option for BAS extraction. They can be tuned to improve both biological and technological properties, resulting in extracts with unique characteristics such as high antioxidant activity, antiproliferative and anti-inflammatory effects, and improved physicochemical properties of macroalgae BAS. In this sense, the tunable design of DES allows optimizing extraction conditions to increase the yield, purity, and biological activity of extracts, making DES an environmentally friendly alternative for the production of biopreparations and other products. The article discusses the potential of DES and outlines the main advantages and solutions to problems in the valorization of macroalgae processing.

Keywords: blue economy, green chemistry, environmental management, renewable resources, extraction, deep eutectic solvents, DES.

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