

Раздел 5. «Химические и фармацевтические технологии. Безопасность жизнедеятельности»IRSTI 31.23.29
UDC: 661.717.3DOI [10.53002/023](https://doi.org/10.53002/023)

I.M.Akmalova, V.V.Merkulov, A.I.Almazov, E.V.Sitdikova

*Karaganda Industrial University, Temirtau, Kazakhstan
(E-mail: ilyanaaa2000@gmail.com)***Waste from oil and fat production as a promising raw material for the synthesis of fatty acid amides**

The fat and fat industry of Kazakhstan plays an important role in the country's agro-industrial complex, providing for the production of vegetable oils, fats and related products. However, this sector also generates a significant amount of waste, including fatty acids, soap glue, sediment and other by-products, which often remain unclaimed or are disposed of with low added value.

With the growing interest in closed-loop technologies and the rational use of natural resources, waste from oil and fat production is a valuable source of raw material for chemical synthesis. In particular, they can be used to obtain fatty acid amides - compounds with a wide range of applications as surfactants, lubricants, polymer modifiers and components of biodegradable materials.

This article discusses the prospects for processing waste from the oil and fat industry of Kazakhstan into fatty acid amides.

Key words: fatty acid amide, surfactants, bactericidal activity, fatty acid, diethanolamine, oil and fat waste.

Main body

Amino derivatives of fatty acids are an important class of chemical compounds with unique properties, which makes them in demand in various industries. These compounds are used in the production of cosmetics, detergents, dietary supplements, and are also used as emulsifiers, stabilizers, and surfactants [1].

Due to the growing need for environmentally friendly and effective chemical compounds, the development of more advanced methods for the synthesis of amino derivatives of fatty acids based on the use of affordable and renewable raw materials, including industrial waste, is becoming an urgent task.

The synthesis of amino derivatives of fatty acids requires a raw material base that must be economically viable and environmentally safe. In recent years, more and more attention has been paid to the use of waste from various industries to obtain valuable chemical compounds. Among such industries, the food, petrochemical and agricultural industries stand out, the waste of which can serve as a valuable source of fatty acids for their further conversion into amino derivatives.

The food industry is one of the most promising sources of raw materials for obtaining fatty acids. In the process of processing products, large volumes of fatty and oil waste are formed, which can be used to synthesize amino derivatives.

The meat and dairy industry produces significant volumes of fats that are not used in the production of final products. These wastes can be processed into fatty acids, which can then serve as raw materials for the synthesis of amino derivatives.

Fat residues from meat products and cream from dairy production can be hydrolyzed to isolate fatty acids, such as stearic, oleic and linoleic acids.

The production of vegetable oils (sunflower, soybean, palm) also produces waste, which includes unnecessary fat fractions. This waste can be used to isolate fatty acids and their subsequent use in chemical synthesis. Residues from the production of sunflower oil contain linoleic and linolenic acids, which can form the basis for the synthesis of amino derivatives.

In plant growing, the main source of fatty acids can be waste after harvesting oil crops such as sunflower, soybean and rapeseed. These wastes can be processed into fatty acids, which will reduce the load on natural

Раздел 5. «Химические и фармацевтические технологии. Безопасность жизнедеятельности»

resources and reduce waste volumes. Sunflower residues after oil pressing contain residual fatty acids that can be used for chemical synthesis [2].

The use of industrial waste for the synthesis of amino derivatives of fatty acids has significant economic and environmental benefits, which makes this approach increasingly attractive in the context of the desire for sustainable development. Recycling waste from the food, petrochemical and agricultural industries allows not only to minimize costs, but also to reduce the negative impact on the environment.

Using waste as a source of raw materials reduces the cost of acquiring new components, as waste often has low or no value. This is especially true for fatty acid amino derivatives, as their traditional precursors are often expensive. Saving on raw materials helps reduce overall production costs and increase profitability.

Industrial waste requires costs for its disposal and storage, which leads to additional costs for enterprises. Recycling this waste into useful products reduces the costs of its disposal, transportation and other aspects of disposal, helping to reduce production costs as a whole.

The production of fatty acid amino derivatives from waste allows for the creation of value-added products. This opens up prospects for introducing new products to the market at competitive prices, which creates opportunities for additional income and new sources of profit for enterprises.

Using local waste reduces dependence on imported raw materials, which can be beneficial in terms of logistics and transportation costs. It also supports regional economies and can create additional jobs in the field of waste recycling. Recycling waste to produce fatty acid amino acids helps reduce the volume of waste sent to landfills. This reduces the area needed for landfilling, extends the life of landfills, and reduces the risk of groundwater and soil contamination from waste [3].

Recycling waste reduces CO₂ and other greenhouse gas emissions associated with the production of raw materials from primary sources. Using waste also reduces emissions associated with the transportation of raw materials and their disposal, which reduces the carbon footprint and helps combat climate change.

Industrial waste may contain toxic substances that pollute the environment if improperly disposed of. Recycling them to fatty acid amino acids helps reduce emissions of harmful substances and improve environmental quality. This approach minimizes the risk of soil, water, and air pollution.

Recycling waste helps use natural resources more rationally, reducing the need to extract new raw materials. This helps conserve natural resources and promotes their sustainable management, which is an important part of an environmentally responsible approach to production. Using waste as a raw material for the production of amino derivatives of fatty acids supports the concept of a closed-loop economy, in which waste from one industry becomes a resource for another. This approach helps reduce waste, create efficient production processes and support sustainable development. Waste from the oil and fat industry is a valuable source of fatty acids for the synthesis of amino derivatives. The use of such waste is not only economically advantageous, but also helps reduce the burden on the environment. Technologies for processing this waste allow them to be effectively used as a raw material for the production of high-quality chemical compounds, which opens up new opportunities for sustainable development and environmentally friendly technologies.

Experimental part

The extraction of fatty acids from the starting fats (lard, chicken fat, linseed oil, etc.) begins with hydrolysis. This process can be carried out using alkaline solutions such as sodium hydroxide to saponify the fats and produce fatty acid salts (soaps) [4].

The product of hydrolysis, fatty acids, is then acidified (usually using hydrochloric acid) to release free fatty acids.

Starting fats and oils:

Vegetable oil (sunflower) - 100 ml.

Palm oil - 100 ml.

Goose fat - 100 g.

Pork fat - 100 g.

Chicken fat - 100 g.

Solutions:

Sodium hydroxide (NaOH) - 10% solution (150 ml for each experiment).

Hydrochloric acid (HCl) – 20% solution (100 ml for each experiment).

Раздел 5. «Химические и фармацевтические технологии. Безопасность жизнедеятельности»

Distilled water (200 ml for washing).

100 g/100 ml of melted fat/plant material were placed in a 500 ml round-bottomed flask. 150 ml of 10% NaOH solution were added. The mixture was heated at 90°C for 2 hours with constant stirring. After cooling, the mixture became viscous, a transparent glycerol phase was formed in it.

50 ml of 20% HCl solution were added, and the mixture was stirred at room temperature. Free fatty acids separated on the surface. Separation was carried out by decantation (Figure 1).



Figure 1– Extraction of fatty acids from feedstock

1. All fats and oils showed a high yield of fatty acids (85-95%), indicating complete conversion of triglycerides.
2. Flaxseed and vegetable oils showed the simplest processing process and a high degree of purity.
3. Palm oil waste required longer heating, but retained the bright natural color of fatty acids.
4. Chicken fat demonstrated the best yield among animal fats.

Carrying out the synthesis of fatty acid amides

Pure fatty acids and amine are placed in a reactor equipped with a heating, stirring and temperature control system. The reaction is carried out at a temperature of 100-150 °C depending on the type of amine and acids used. The temperature regime is selected in such a way as to ensure a high reaction rate, but minimize side processes, such as acid decomposition. During the reaction, the amine interacts with the carboxyl group of the fatty acid, forming an amide. (Figure 2)

This reaction can proceed without the use of solvents, or in the presence of a small amount of water or organic solvent to facilitate mixing and regulate the viscosity of the mixture.

Раздел 5. «Химические и фармацевтические технологии. Безопасность жизнедеятельности»

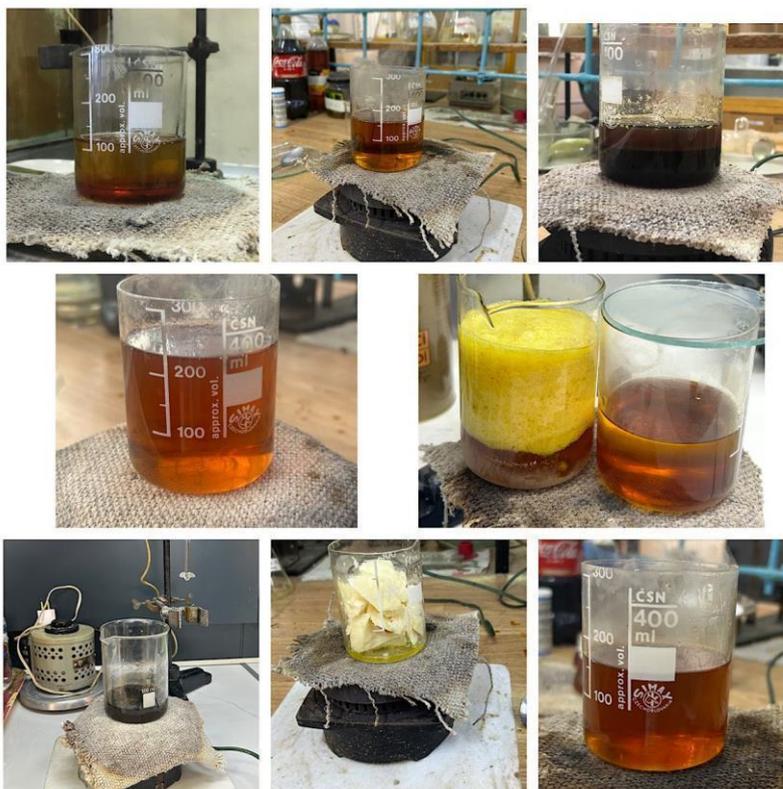


Figure 2 – Synthesis of fatty acid amides

After the reaction is complete, the mixture is cooled and the target product (fatty acid amide) is separated from unreacted substances and by-products. Depending on the solubility of the amides and possible impurities, extraction with organic solvents or washing with water can be used.

Purification can be carried out by vacuum distillation to remove the remaining unreacted acids and amines, which allows obtaining a pure amide. Vacuum distillation reduces the boiling point of the components, which minimizes the risk of their decomposition.

Conclusion

The use of waste from oil and fat production as a raw material for the synthesis of amino derivatives of fatty acids is a promising direction that combines economic benefits and environmental feasibility. In the context of growing demand for environmentally friendly and sustainable technologies, the processing of by-products of the oil and fat industry allows reducing waste disposal costs, reducing the burden on the environment and creating products with high added value.

The use of such waste in the synthesis of amino derivatives of fatty acids contributes to the development of the concept of a closed-loop economy, in which the waste of one industry becomes a valuable resource for another. This is especially relevant for Kazakhstan, where the fat and oil industry is one of the significant sectors of the food industry, and the efficient use of its waste will minimize the negative impact on the environment and increase the economic efficiency of production. Thus, the processing of fat and oil industry waste into fatty acid amides is an important step in the development of environmentally friendly technologies and can become the basis for the creation of new high-tech industries in Kazakhstan [5].

References

1. Akmalova I.M., Merkulov V.V., Almazov A.I., Sitdikova E.V. Study of the properties of a new detergent based on cationic surfactants: Proceedings of the XI International Scientific and Practical Conference "Science and Education in the Modern World: Challenges of the XXI Century" (Astana, October 25, 2022)

Раздел 5. «Химические и фармацевтические технологии. Безопасность жизнедеятельности»

Astana: Publishing House of the Association of Legal Entities "National Movement "Bobek". - 2022. - P. 25-30

2. Merkulov V.V., Akmalova I.M., Almazov A.I., Sitdikova E.V., Gavva N.F. Method for obtaining surfactants based on various fatty raw materials // International Journal of Applied and Fundamental Research. - 2022. - No. 12. - P. 117-121. doi.org/10.17513/mjpf.13494

3. Wang X., Han Z., Chen Y., Jin Q. Scalable synthesis of oleoyl ethanolamide by chemical amidation in a mixed solvent // Journal of the American Oil Chemists Society. – 2016. –V. 93. –P. 125–131.

4. Akmalova I.M., Merkulov V.V. Method of obtaining surfactants based on various fatty raw materials // News of the National Academy of Sciences of the Republic of Kazakhstan. Chemistry and Technology Series. –2023. –No. 2. –P. 5–14. doi.org/10.32014/2023.2518–1491.158

5. Our newspaper // Kostanay regional portal. [Electronic resource]. URL: <https://www.ng.kz/modules/news/article.php?storyid=45257>

И.М.Акмалова, В.В. Меркулов, А.И. Алмазов, Е.В.Ситдикова

Май қышқылдары амидтерін синтездеу үшін перспективалық шикізат ретінде май және май өндірісінің қалдықтары

Қазақстанның май және тоң май өнеркәсібі елдің агроөнеркәсіп кешенінде өсімдік майын, тоң май және онымен байланысты өнімдерді өндіруді қамтамасыз ететін маңызды орын алады. Дегенмен, бұл сектор сонымен қатар май қышқылдарын, сабын шламын, қалдықтарды және басқа да жанама өнімдерді қоса алғанда, елеулі көлемдегі қалдықтарды тудырады, олар жиі пайдаланылмайды немесе қосымша құны төмен кәдеге жаратылады. Жабық циклді технологияларға және табиғи ресурстарды ұтымды пайдалануға қызығушылықтың артуы жағдайында мұнай және май өндірісінің қалдықтары химиялық синтез үшін шикізаттың құнды көзі болып табылады. Атап айтқанда, олар май қышқылдарының амидтерін, беттік-белсенді заттар, майлау материалдары, полимер модификаторлары және биологиялық ыдырайтын материалдардың құрамдас бөліктері ретінде қолданудың кең ауқымы бар қосылыстарды өндіру үшін пайдаланылуы мүмкін. Бұл мақалада Қазақстанның мұнай және тоң май өнеркәсібінің қалдықтарын май қышқылы амидтеріне өңдеу перспективалары қарастырылады.

Негізгі сөздер: май қышқылы амиді, беттік белсенді заттар, бактерицидтік белсенділік, май қышқылы, диетаноламин, май және май қалдықтары.

И.М.Акмалова, В.В. Меркулов, А.И. Алмазов, Е.В.Ситдикова

Отходы масложирового производства как перспективное сырье для синтеза амидов жирных кислот

Масложировая промышленность Казахстана занимает важное место в агропромышленном комплексе страны, обеспечивая производство растительных масел, жиров и сопутствующих продуктов. Однако этот сектор также генерирует значительные объемы отходов, включая жирные кислоты, мыльный шлам, остатки и другие побочные продукты, которые часто не используются или утилизируются с незначительной добавленной стоимостью.

В связи с растущим интересом к технологиям замкнутого цикла и рациональному использованию природных ресурсов отходы нефти и нефтедобычи становятся ценным источником сырья для химического синтеза. В частности, их можно использовать для получения амидов жирных кислот – соединений с широким спектром применения в качестве поверхностно-активных веществ, смазочных материалов, модификаторов полимеров и компонентов биоразлагаемых материалов.

Раздел 5. «Химические и фармацевтические технологии. Безопасность жизнедеятельности»

В данной статье рассматриваются перспективы переработки отходов масложировой промышленности Казахстана в амиды жирных кислот.

Ключевые слова: амиды жирных кислот, поверхностно-активные вещества, бактерицидная активность, жирные кислоты, диэтаноламин, остатки масел и жиров.

Список литературы

1. Акмалова И.М., Меркулов В.В., Алмазов А.И., Ситдикова Э.В. Исследование свойств нового моющего средства на основе катионных ПАВ // Наука и образование в современном мире: вызовы XXI века: материалы XI Междунар. науч.-практ. конф. (Астана, 25 окт. 2022 г.). – Астана: Изд-во Ассоциации юрид. лиц «Нац. движение «Бобек», 2022. – С. 25–30.
2. Меркулов В.В., Акмалова И.М., Алмазов А.И., Ситдикова Э.В., Гавва Н.Ф. Метод получения поверхностно-активных веществ на основе различных жировых сырьевых компонентов // Международный журнал прикладных и фундаментальных исследований. – 2022. – № 12. – С. 117–121. – DOI: <https://doi.org/10.17513/mjprfi.13494>.
3. Ван С., Хань Ч., Чэнь Ю., Цзинь Ц. Масштабируемый синтез олеилэтаноламида методом химической амидизации в смешанном растворителе // Журнал Американского общества химиков масел. – 2016. – Т. 93. – С. 125–131.
4. Акмалова И.М., Меркулов В.В. Способ получения поверхностно-активных веществ на основе различных жировых сырьевых компонентов // Вестник Национальной академии наук Республики Казахстан. Серия химии и технологии. – 2023. – № 2. – С. 5–14. – DOI: <https://doi.org/10.32014/2023.2518-1491.158>.
5. Наша газета // Костанайский региональный портал [Электронный ресурс]. – URL: <https://www.ng.kz/modules/news/article.php?storyid=45257>.