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PRODUCTION OF MELAMINE USING THE ELECTROLYSIS METHOD

Melamine is the most important raw material in the paint industry and in the production of plastics. Melamine is also widely used in electrical engineering and textiles. Such widespread use has led to rapid growth in melamine production worldwide. The products of the organic synthesis industry are used in many fields and differ from other industrial products due to their different structure. Currently, the synthesis of melamine is carried out at high pressures and high temperatures or in the presence of catalysts, which complicates the technology.

In this article, the technology of obtaining melamine using the electrolysis method is studied. The characteristics and schematic structure of the experimental device are presented. The synthesized melamine was analyzed using IR spectroscopy and NMR spectroscopy to confirm its chemical composition and structural properties. The IR spectra revealed characteristic peaks corresponding to primary amine groups and the triazine ring, confirming successful melamine synthesis. The study demonstrates the feasibility and advantages of using electrolysis for melamine synthesis, including reduced environmental impact and simplified technological processes. This innovative method holds significant potential for industrial application, offering a more economical and eco-friendly solution for the production of melamine and other organic compounds.

Key words: melamine, electrolysis, urea, ammonium chloride, IR spectrum, power source.

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Электролиз әдісімен меламин өндіру

Меламин бояу өнеркәсібіндегі және пластмасса өндірісіндегі ең маңызды шикізат болып табылады. Меламин электротехника мен тоқыма өнеркәсібінде де кеңінен қолданылады. Мұндай кеңінен қолдану бүкіл әлемде меламин өндірісінің жылдам өсуіне әкелді. Органикалық синтез өнеркәсібінің өнімдері көптеген салаларда қолданылады және құрылымы әртүрлі болғандықтан басқа өнеркәсіптік өнімдерден ерекшеленеді. Қазіргі уақытта меламин синтезі жоғары қысымда және жоғары температурада немесе катализаторлардың қатысуымен жүзеге асырылады, бұл технологияны қиындатады.

Бұл мақалада электролиз әдісімен меламин алу технологиясы зерттеледі. Эксперименттік құрылғының сипаттамалары мен схемалық құрылымы берілген. Синтезделген меламин химиялық құрамы мен құрылымдық қасиеттерін растау үшін ИҚ-спектроскопия және ЯМР спектроскопиясы арқылы талданды. ИҚ спектрлері меламиннің сәтті синтезін растайтын бастапқы амин топтары мен триазин сақинасына сәйкес келетін сипаттамалық шыңдарды анықтады. Зерттеу меламинді синтездеу үшін электролизді пайдаланудың орындылығы мен артықшылықтарын көрсетеді, соның ішінде қоршаған ортаға әсерді азайту және оңайлатылған технологиялық технологиялар. Бұл инновациялық әдіс меламин және басқа да органикалық қосылыстарды өндіру үшін үнемді және экологиялық таза шешім ұсына отырып, өнеркәсіптік қолдану үшін айтарлықтай әлеуетке ие.

Түйін сөздер: меламин, электролиз, мочевина, аммоний хлориді, ИҚ спектрі, қуат көзі.

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Производство меламина методом электролиза

Меламин является важнейшим сырьем в лакокрасочной промышленности и производстве пластмасс. Меламин также широко используется в электротехнике и текстильной промышленности. Такое широкое применение привело к быстрому росту производства меламина во всем мире. Продукция промышленности органического синтеза используется во многих областях и отличается от других промышленных продуктов своей иной структурой. В настоящее время синтез меламина осуществляется при высоких давлениях и высоких температурах или в присутствии катализаторов, что усложняет технологию.

В данной статье изучается технология получения меламина методом электролиза. Представлены характеристики и схематическая структура экспериментального устройства. Синтезированный меламин был проанализирован с помощью ИК-спектроскопии и ЯМР-спектроскопии для подтверждения его химического состава и структурных свойств. ИК-спектры выявили характерные пики, соответствующие первичным аминогруппам и триазиновому кольцу, что подтверждает успешный синтез меламина. Исследование демонстрирует осуществимость и преимущества использования электролиза для синтеза меламина, включая снижение воздействия на окружающую среду и упрощение технологических процессов. Этот инновационный метод имеет значительный потенциал для промышленного применения, предлагая более экономичное и экологичное решение для производства меламина и других органических соединений.

Ключевые слова: меламин, электролиз, мочевина, хлорид аммония, ИК-спектр, источник питания.

Introduction

Melamine is a key organic chemical intermediate with a wide range of uses. Melamine is the most important raw material in the paint industry and plastic production [1,2]. Products based on melamine-formaldehyde are used for paper production and furniture. The main use of melamine in the wood industry is more than 70% of the total consumption (Fig.1) [3]. The development of this industry is determined by the availability of domestic market capacity and the ever-increasing demand for this product. Melamine is also widely used in electrical engineering and textiles. Such widespread use has led to rapid growth in melamine production worldwide [4-8]. The chemical formula of melamine (2,4,6-triamino,1,3,5-triazine) shows its structure and shows some similarity with the benzene nucleus. Both the benzene and triazine rings are characterized by their stability [9].

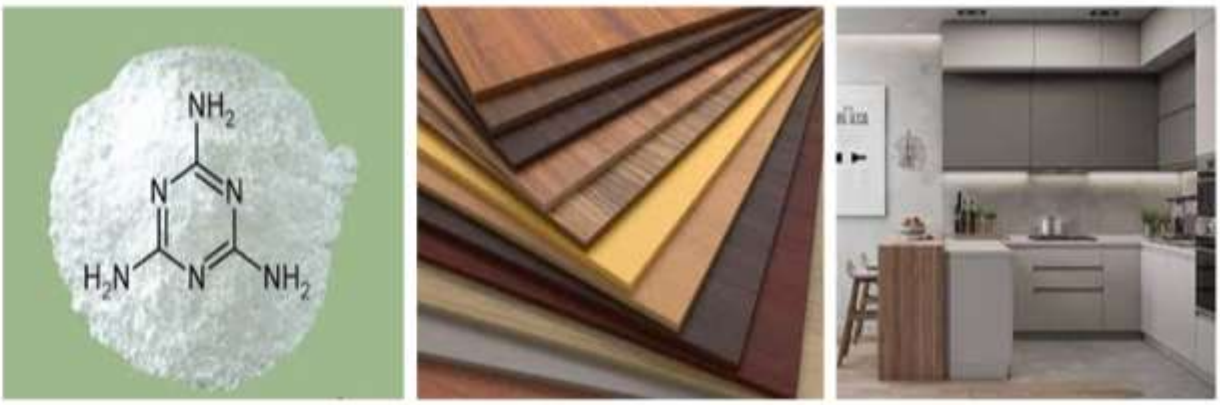


Figure 1 – Furniture made on the basis of melamine

Melamine was first synthesized in 1834 by Lee Bishi. Initially, the dicyandiamide method was used. In this case, calcium cyanamide ($CaCN_2$) is prepared from calcium carbide (CaC_2), calcium cyanamide is hydrolyzed and dimerized into dicyandiamide, then heated and decomposed. Due to the high cost of calcium carbide, this method is not currently used. At present, industrial synthesis mainly uses urea as a raw material [10,11].

$$6(NH_2)_2CO = C_3H_6N_6 + 6NH_3 + 3CO_2$$

According to different reaction conditions, synthesis processes can be divided into high-pressure, low-pressure and atmospheric-pressure methods.

1. In the production of melamine by the high-pressure method, dissolved urea is usually sent to the compression breaker under a pressure of 8-9 MPa and then enters the synthesis reactor: in addition, liquid ammonia is under a pressure of 8-9.5 MPa [12]. The temperature is heated up to 400 °C. A catalyst is not involved in this.
2. In the production of melamine through a low-pressure process, the reaction takes place under a pressure of 0.1-1.0 MPa. The temperature will be up to 170-200 °C. Catalysts are used in this.
3. In the production of melamine by the atmospheric pressure method, ammonia gas from the synthetic ammonia section, pressure 0.10-0.15 MPa, is sent directly to the melamine section. After preheating to 350-400 °C with steam and molten salt, ammonia is used as gas fluid layer carrier. A catalyst is also used in this method [13,14].

Materials and Methods

These methods complicate the technology because they are carried out at high pressures and high temperatures or in the presence of catalysts. In addition, secondary products released after the reaction, toxic gases and dirty water cause environmental pollution.

The method we recommend involves the use of electrolysis in the synthesis of melamine. The structure of the device is shown in Fig. 2.

Graphite, a material with good electrical conductivity and easy processing, was used as the cathode and anode electrodes. Urea and ammonium chloride are poured into the electrolyzer and the process of obtaining melamine at different current densities is studied.

Results and discussion

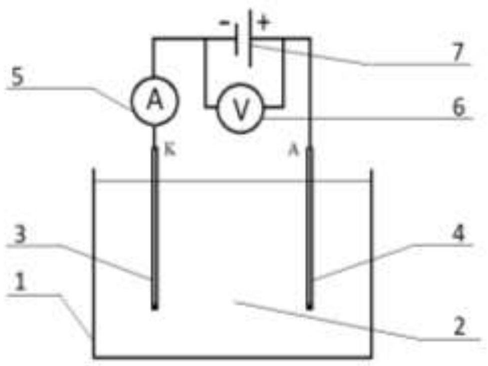
In the experiment, the composition and structure of the synthesized substance was studied using IR-spectroscopy and NMR-spectroscopy method.

IR-spectroscopy analysis

IR-spectroscopic analyzes were carried out on a Shimadzu IR Tracer-100 instrument manufactured in Japan. The presence of various functional groups in the samples was studied in the frequency range of 400-4000 cm^{-1} [15,16]. IR spectroscopic analysis is widely used to determine the presence of appropriate functional groups in substances. The greater the amount of these functional groups, the higher their intensity.

NMR spectra were determined on a JNM-ECZ600R spectrometer made in Japan at 600 MHz in DMSO-d6+CCl_4 solutions for ^1H. TMC (0 ppm) was used as standard in ^1H NMR spectra. For ^{13}C, it was determined at a frequency of 150 MHz. In NMR spectra, the chemical shift of the solvent was taken into account as a standard. ^1H NMR and ^{13}C NMR spectral analysis are two important analytical techniques used to study the structure of organic compounds. The melamine peak was seen at 5.47; 3.4; and 2.5 ppm because of rapid proton exchange with the solvent proton on the NH_2 groups. The high signals at 149.8 and 159.9 ppm in the ^{13}C NMR spectrum may belong to the triazine moiety of melamine. The results of this analysis confirm the formation of melamine.

The IR-spectrum of the substance obtained by the electrolysis method is presented in Fig. 3. It can be seen that the valence vibrations of the primary amine groups of melamine are located in the region of 3468 cm^{-1} and 3417 cm^{-1}. The valence vibrations of the NH bonds located in this interval are intense and have a narrow band in the independent state. Vibrations of the 1,3,5 triazine ring are observed in the region of 1622; 1525; 1463 and 1431 cm^{-1}. The results of this analysis confirm the formation of melamine.



1 is electrolyzer, 2 is reactive substances, 3 is cathode, 4 is anode, 5 is ammeter, 6 is voltmeter, 7 is power source.

Figure 2 –Schematic structure of the device

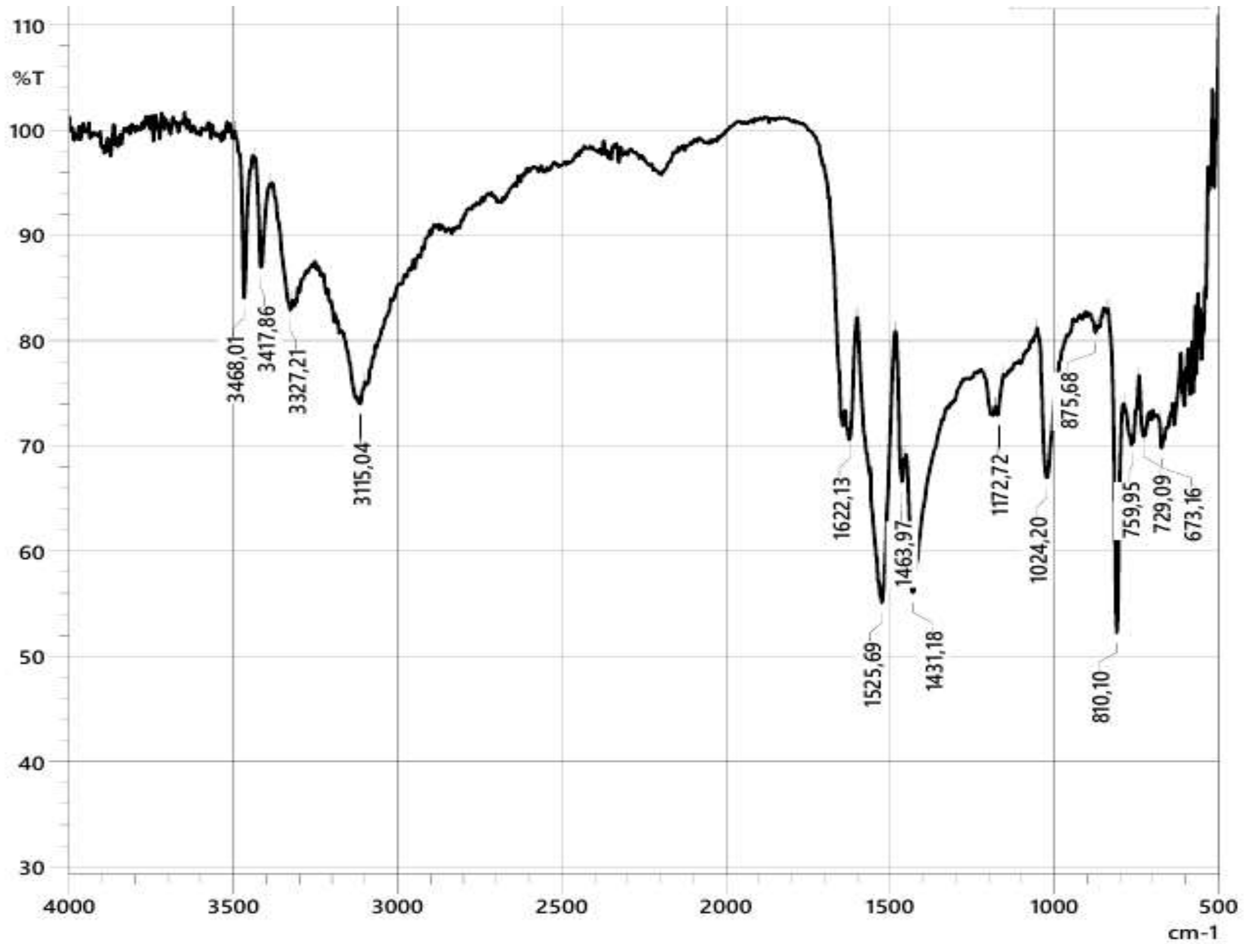


Figure 3 – IR spectrum of melamine synthesized by electrolysis method

NMR-spectroscopy method

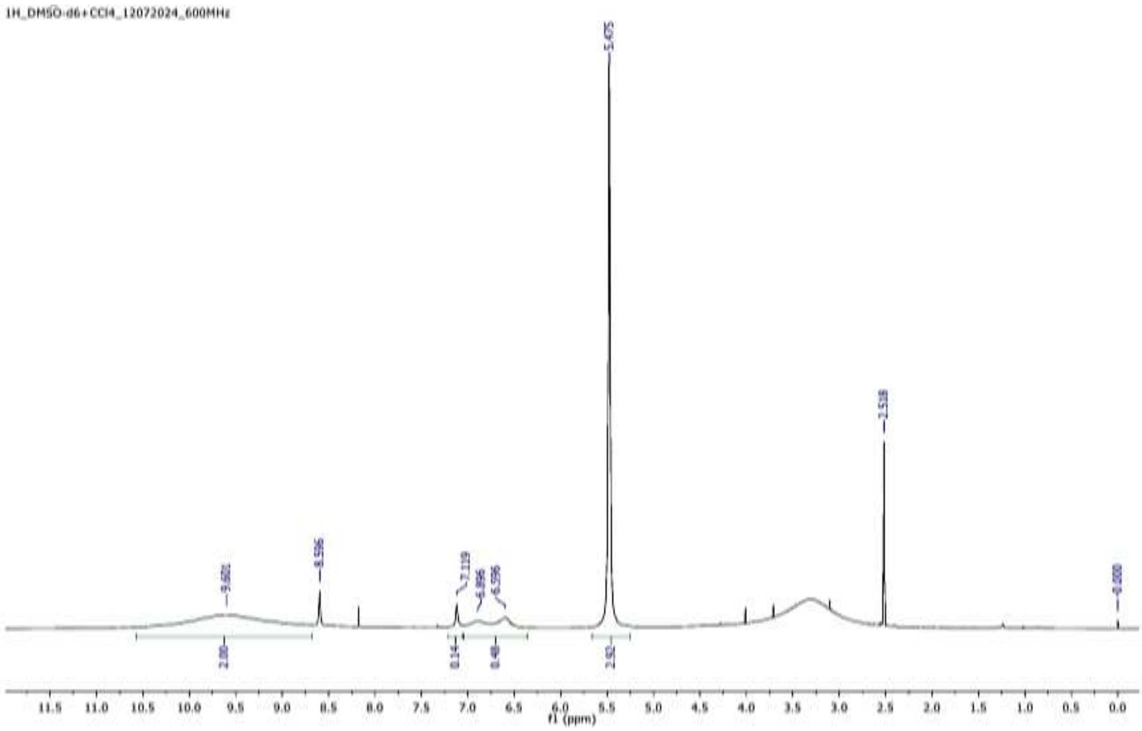
This method is a radiospectroscopic method that studies the interaction of matter with radiofrequency radiation. This method is based on the phenomenon of magnetic resonance, the phenomenon of resonant transitions between the magnetic energy levels of atomic nuclei in an external magnet [16,17]. The PMR method is used to study the molecular structure, dynamics of intermolecular interactions, chemical reaction mechanism and quantitative analysis of substances. The substance to be studied by the NMR method must have diamagnetic properties. The nucleus of the atoms of matter must have magnetic properties, that is, the nuclear spin must be different from zero.

NMR spectra were determined on a JNM-ECZ600R spectrometer made in Japan at 600 MHz in DMSO-d6+CCl_4 solutions for ^{1}H. TMC (0 ppm) was used as standard in ^{1}H NMR spectra. For ^{13}C, it was determined at a frequency of 150 MHz. In NMR spectra, the chemical shift of the solvent was taken into account as a standard. ^{1}H NMR and ^{13}C NMR spectral analysis are two important analytical techniques used to study the structure of organic compounds. The melamine peak was seen at 5.47; 3.4; and 2.5 ppm because of rapid proton exchange with the solvent proton on the NH_2 groups (Fig.4). The high signals at 149.8 and 159.9 ppm in the ^{13}C NMR spectrum may belong to the triazine moiety of melamine. The results of this analysis confirm the formation of melamine.

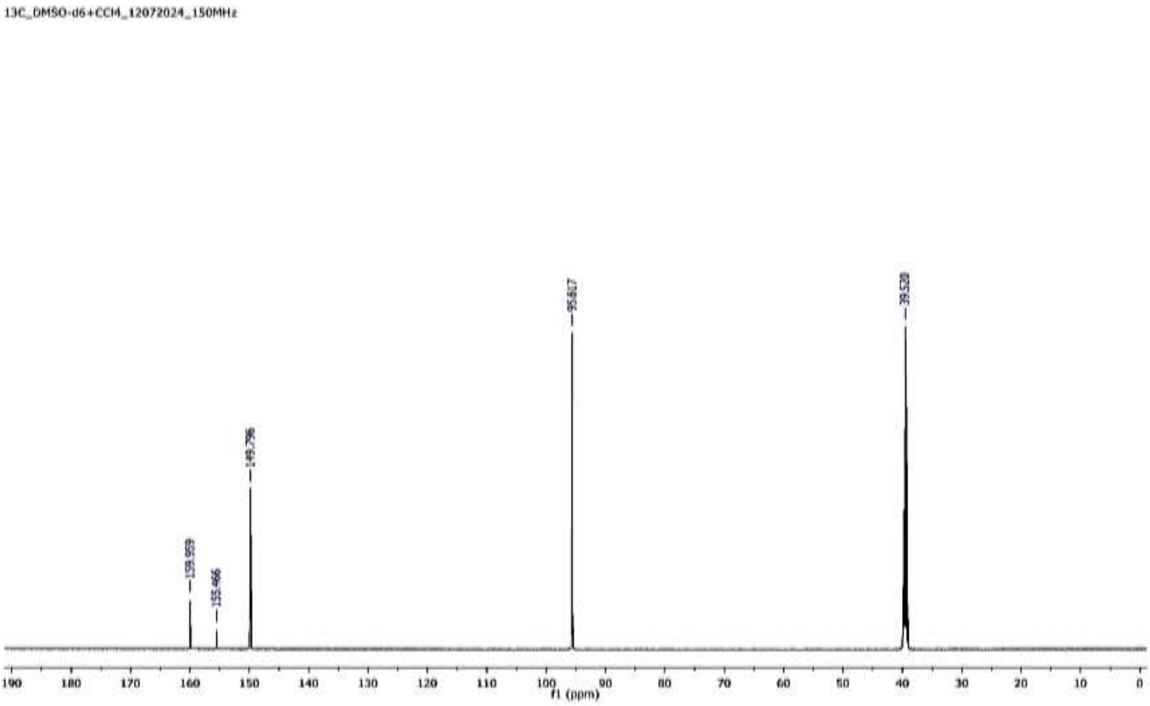
Conclusion

Synthesis of melamine using the electrolysis method has several advantages over traditional methods used in industry. We don't need high pressure or high temperature. We do not use complex multi-step technology.

Therefore, in the future, it is necessary to introduce the use of the electrolysis method in the synthesis of melamine and other organic substances on an industrial scale.



a)



b)

Figure 4 – NMR spectrum of synthesized melamine

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