

The Impact of Storage Conditions on the Physicochemical Properties of Electrochemically Activated Solutions

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ABSTRACT

Introduction: Microbiological safety in food production is closely linked to the implementation of sanitary, hygienic, and anti-epidemic measures, where disinfectants play a critical role. The effectiveness of disinfectants largely depends on their stability and changes in physicochemical properties during storage. Existing literature highlights the insufficient study of the wetting properties of electrochemically activated solutions (ECAS) of anolytes in conjunction with traditionally analyzed characteristics such as active chlorine content, hydrogen ion activity (pH), and oxidation-reduction potential (ORP).

Purpose: To investigate the impact of storage conditions on the physicochemical properties of electrochemically activated neutral and acidic anolytes, including their wettability and stability.

Materials and Methods: The study objects were acidic and neutral electrochemically activated solutions obtained using electrolysis systems. The stability of anolyte solutions was evaluated based on active chlorine content, oxidation-reduction potential (ORP), and pH values. Wettability was assessed by the contact angle (CA) in a three-phase system using the Young-Laplace method.

Results: During the 70-day storage of acidic anolytes, ORP decreased compared to the initial solution, with the rate of decline depending on storage conditions and the most significant drop occurring in the initial days. For neutral anolyte samples, no significant ORP reduction was observed. However, samples stored in containers of different materials at a temperature of 5 ± 1 showed a slight increase in ORP, which stabilized after 15–20 days. In neutral anolytes, the rate of active chlorine decrease was significantly lower than in acidic anolytes and correlated with pH reductions. This may be attributed to the formation of chlorine-containing acids in stored samples, shifting the solutions from neutral to acidic. The contact angle (CA) of anolytes on stainless steel surfaces after storage was comparable to the CA of a 0.1 N hydrochloric acid solution.

Conclusion: Storage conditions significantly influence the physicochemical and consumer properties of anolytes. Under different storage conditions, temperature is the most critical factor determining the stability of both acidic and neutral anolytes. Neutral anolytes are preferable for use and storage but require adherence to specific conditions. Neutral ECAS anolytes should be stored in closed glass, stainless steel, or enamel containers in a cool, dark place, away from heat sources and direct sunlight, at temperatures ranging from 0°C to +8°C, while following proper storage compatibility principles.

Keywords: electrochemically activated solutions; anolyte; chlorine-based disinfectants; oxidation-reduction potential; active chlorine; wettability

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Влияние условий хранения на физико-химические свойства электрохимически активированных растворов

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АННОТАЦИЯ

Введение: Микробиологическая безопасность производства пищевых продуктов неразрывно связана с проведением санитарно-гигиенических и противоэпидемических мероприятий, в которых немаловажная роль принадлежит использованию дезинфицирующих средств. Значимыми составляющими эффективности дезинфектантов являются их стабильность и изменения физико-химических свойств в процессе хранения. Существующая литература по теме свидетельствует о недостаточной изученности смачивающих свойств электрохимически активированных растворов (ЭХАР) анолитов в совокупности с такими традиционно анализируемыми характеристиками, как содержание активного хлора, показатель активности водородных ионов и окислительно-восстановительный потенциал (ОВП).

Цель: Исследовать влияние условий хранения электрохимически активированных растворов нейтральных и кислотных анолитов на их физико-химические свойства, в том числе смачиваемость и стабильность.

Материалы и методы: Объектами исследований являются: кислотные и нейтральные электрохимически активированные растворы, получаемые на электролизных установках. Стабильность растворов анолитов оценивали по содержанию активного хлора, окислительно-восстановительному потенциалу (ОВП) и показателю активности водородных ионов (рН). Смачивающую способность оценивали по краевому углу смачивания (КУС) в 3-х фазной системе по методу Юнга-Лапласа.

Результаты: При хранении кислотных анолитов в течение 70 дней ОВП снижается по сравнению с исходным раствором, при этом скорость снижения зависит от условий хранения с наибольшим падением в первые дни хранения. У образцов нейтрального анолита существенного уменьшения ОВП не наблюдалось, однако для образцов, хранящихся в емкостях из различных материалов при температуре 5 ± 1 °C был отмечен определенный рост ОВП, который через 15–20 дней стабилизировался. У растворов нейтрального анолита скорость падения активного хлора существенно ниже, чем у кислотных анолитов и сопоставима с результатами снижения показателя рН данных растворов, что может быть интерпретировано образованием хлорсодержащих кислот в хранившихся образцах, которые переводили растворы из нейтральной среды в кислую. КУС анолита по отношению к поверхности из нержавеющей стали после хранения сопоставим со значением КУС 0,1 н раствора соляной кислоты.

Выводы: Условия хранения ЭХАР оказывают существенное влияние на физико-химические и потребительские свойства анолитов. При различных условиях хранения как кислотных, так и нейтральных анолитов температурный фактор является важнейшим, определяющим стабильность этих растворов. Использование и хранение растворов нейтральных анолитов предпочтительнее, чем кислотных, но требует соблюдения определенных условий. ЭХАР нейтральных анолитов должны храниться в закрытых стеклянных, нержавеющей или эмалированных емкостях в прохладном темном месте, вдали от нагревательных приборов, не допуская попадания прямых солнечных лучей при температуре от 0 °C до плюс 8 °C при соблюдении принципов товарного соседства.

Ключевые слова: электрохимически активированные растворы; анолит; хлорактивные средства, окислительно-восстановительный потенциал; активный хлор; смачиваемость

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INTRODUCTION

Sanitary treatment, or sanitization, is an integral part of any food production that has a direct effect on the quality and safety of the products. Sanitary treatment¹ is a set of measures taken to eliminate various types of contamination with detergents or cleaning agents and followed by preventive disinfection².

There is a great demand for new disinfectants for sanitization due to the growing resistance of various microorganisms to antimicrobial drugs, especially in medical institutions (Bessarabova, 2021), agriculture (Metleva, 2021), and in the food industry (Semenikhina, 2020), where certain restrictions are imposed on the use of biocides in food enterprises. New disinfectants should have a high bactericidal effect at low concentrations and a minimal toxic effect on the human body.

Chlorine-active preparations are the most well-studied disinfectants used in dairy enterprises. They are considered the most reliable and effective disinfectants available at low cost (Manevich, 2007; Kuzina, 2015).

Electrochemically activated (ECA) solutions are safe for the human body and the environment (Park, 2007; Garcia-Rodriguez, 2022; Pankratova, 2023), since they decompose into salts and water due to chemical relaxation. In general, ECA anolyte solutions have been positively assessed in the food industry (He, 2021; Shi, 2023). They have been used for disinfecting various contact surfaces (Yan, 2021) or treating certain food products (Kovaliova, 2022; Pivovarov, 2022). ECA solutions act as a “green biocide” by reducing the use of active chlorine (Scialdone, 2021; Aniyyah, 2022) and making the disposal of toxic chemicals more environmentally friendly.

Changes in the physicochemical properties (active chlorine, pH, redox potential) of electrochemically activated solutions determine their storage stability, which is not only the most important indicator of their quality, but is also responsible for their disinfectant efficacy against unwanted microflora (Nisola, 2011; Clayton, 2021; Mohammadi, 2021).

The main advantage of ECA solutions is that they can be obtained directly at the production site from water, salt,

and electricity. This eliminates the need to transport and store large volumes of liquid disinfectants, which can have certain environmental consequences. However, there may be situations when ECA solutions have to be stored and transported. For example, there may be a lack of electricity or sodium chloride, or an electrolysis unit cannot be installed at the production site. Therefore, ECA solutions of acid and neutral anolytes need to be studied under various storage conditions to detect changes in their wetting ability and other related properties that ensure their biocidal efficacy and safety as biocides.

Previous publications (Manevich, 2019; Manevich, 2022; Manevich, 2023) emphasized the importance of wetting the surfaces exposed to washing and disinfection for effective sanitization. This substantiates the need to evaluate the wetting properties of anolyte on a test surface made of chromium-nickel stainless steel imitating the surface of process equipment.

In this study, we aimed to evaluate the effect of storage conditions on the wetting and physicochemical properties (pH, redox potential, active chlorine) of acidic and neutral anolytes. Together, these properties determine the stability of ECA solutions in a significantly longer period (70 days).

Our study sought to answer the following questions:

- (1) How do storage conditions for neutral and acidic ECA solutions affect their redox potential?
- (2) How do storage conditions for neutral and acidic ECA solutions affect their pH?
- (3) Do storage conditions for neutral and acidic ECA solutions affect the content of active chlorine in the anolytes?
- (4) How much do the wetting properties of neutral anolyte change during storage?

¹ State Standard R 54762–2011/ISO/TS 22002–1:2009 “Prerequisite Programmes on Food Safety. Food Manufacturing”

² Filchakova, S. (2008). Sanitation and Hygiene at Dairy Enterprises. Delhi Print.

MATERIALS AND METHODS

Study objects

Our study objects were electrochemically activated solutions of acidic and neutral anolytes.

Materials

Electrochemically activated solutions were prepared from tap water, distilled water (State Standard 6709–72), chemically pure sodium chloride (State Standard 4233–77), standard-titer 5 % aqueous sodium sulfate (sodium thiosulfate) (Specifications 6–09-2540–87), potassium iodide (State Standard 4232), and sulfuric acid (State Standard 4204).

Equipment

The equipment and facilities used in the study included an AQUATRON-17-L laboratory unit (Figure 1A); a STEL-ANK-SUPER unit (Figure 1B); ML 0.6-II VZhA electronic scales; a TOP Buret H semi-automatic titrator; a Hanna Instruments HI991001 pH-meter with an HI1296D electrode; a pH-150 MI pH-meter with a glass electrode having a red-ox function; and a DSA25S drop shape analyzer for measuring the contact angle (Krüss Optronic GmbH, Germany).

Methods

Preparation of Anolytes

Acid anolyte samples were obtained in the AQUATRON-17-L unit equipped with an RPE-2 electrochemical reactor consisting of two MB-11T electrochemical Bakhir modules with a platinum anode coating. Neutral anolyte (ANK-SUPER) samples were obtained in the STEL-ANK-SUPER unit.

Solutions of acid and neutral anolytes were prepared in accordance with the operation manuals for the AQUATRON-17-L and STEL-ANK-SUPER units.

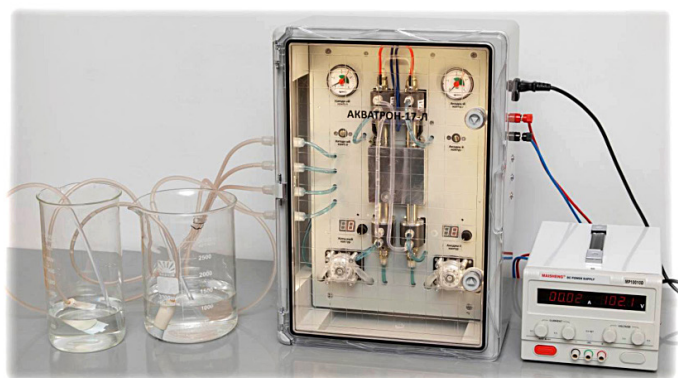
The electrochemical units were used to electrolyze aqueous solutions of chemically pure sodium chloride.

Preparation of Acid Anolyte

A weighed portion of sodium chloride salt (18 g) was dissolved in a 2-liter measuring flask until completely dissolved. Then, the solution was transferred to a container and pump hoses connected to the AQUATRON-17-L unit were immersed in it. An electrochemically activated solution of acidic anolyte was obtained at 2.0 A and an electrochemical treatment time of 60 minutes.

Figure 1

Units for Electrochemical Treatment of Water and Aqueous Solutions: AQUATRON-17-L (A), STEL-ANK-SUPER (B)



A



B

Preparation of Neutral Anolyte

A weighed portion of sodium chloride salt (10 g) was dissolved in a 2-liter measuring flask until completely dissolved. Then, the solution was transferred to a container and pump hoses connected to the STEL-ANK-SUPER unit were immersed in it. To obtain neutral anolyte (ANK), the feed solution flew through the electrode chamber of a single PEM-3 element at 15 l/h, and the current flowing through a single PEM-3 element was 5 A.

Determination of Active Chlorine Content

The content of active chlorine in the electrochemically activated anolyte solutions was determined by iodometric titration according to State Standard R 57001–2016¹.

Determination of pH

The activity of hydrogen ions (pH) in the electrochemically activated anolyte solutions was determined by the potentiometric method using a Hanna Instruments HI991001 pH-meter with an HI1296D electrode according to State Standard 32385–2013².

Determination of Redox Potential

The redox potential of the electrochemically activated anolyte solutions was determined by the electrochemical method using a pH-150 MI device with a glass electrode

having a redox function relative to a standard hydrogen electrode.

Determination of Wetting Ability

The wetting ability of the electrochemically activated anolyte solutions was assessed by measuring the contact angle (WEA, θ) in a 3-phase system: adhesive (anolyte) — substrate (test plate made of austenitic stainless steel, grade 08X18H10T, roughness class 9, $R_a = 0.2\text{--}0.3\text{ }\mu\text{m}$) — air. For this, the sessile drop method was applied according to the Young-Laplace method using a DSA25S drop shape analyzer (Krüss Optronic GmbH, Germany) and Krüss Advance 1.12.2.06901 software.

Study Design

Our study consisted of several successive stages. First, we prepared electrochemically activated solutions of acidic and neutral anolytes and selected conditions (Table 1) for their storage during 70 days. Then, we determined changes in the redox potential, pH, and the content of active chlorine in the neutral and acidic anolytes. Finally, we assessed changes in the wetting ability of the neutral anolyte after storage. The main physicochemical indicators (active chlorine content, redox potential, pH, wetting ability) were monitored throughout storage with an interval of 5 days.

Table 1
Storage Conditions for Electrochemically Activated Solutions

Solution No.	pH of solution	Storage conditions	Storage material
Solution 1	2.20	Bright room (25±1 °C)	Polypropylene
Solution 2		Dark room (20±1 °C)	
Solution 3		Dark room (5±1 °C)	
Solution 4		Bright room (25±1 °C)	Glass
Solution 5		Dark room (20±1 °C)	
Solution 6		Dark room (5±1 °C)	
Solution 7	6.48	Bright room (25±1 °C)	Polypropylene
Solution 8		Dark room (20±1 °C)	
Solution 9		Dark room (5±1 °C)	
Solution 10		Bright room (25±1 °C)	Glass
Solution 11		Dark room (20±1 °C)	
Solution 12		Dark room (5±1 °C)	

¹ Disinfectology and disinfection activities. Chemical disinfectants and antiseptics.
² Household chemicals. A method for determining the hydrogen ion activity index (pH).

Data Analysis

All the experiments were performed in three to five repetitions. The results were presented as mean $\pm$ standard deviation. Standard statistical methods were applied to process the data. Analysis of variance (ANOVA) was performed with the Minitab Statistical Software (USA, 2023). The tables and graphs were constructed in the Microsoft Office programs.

RESULTS

Different storage conditions affected the following parameters of the electrochemically activated solutions

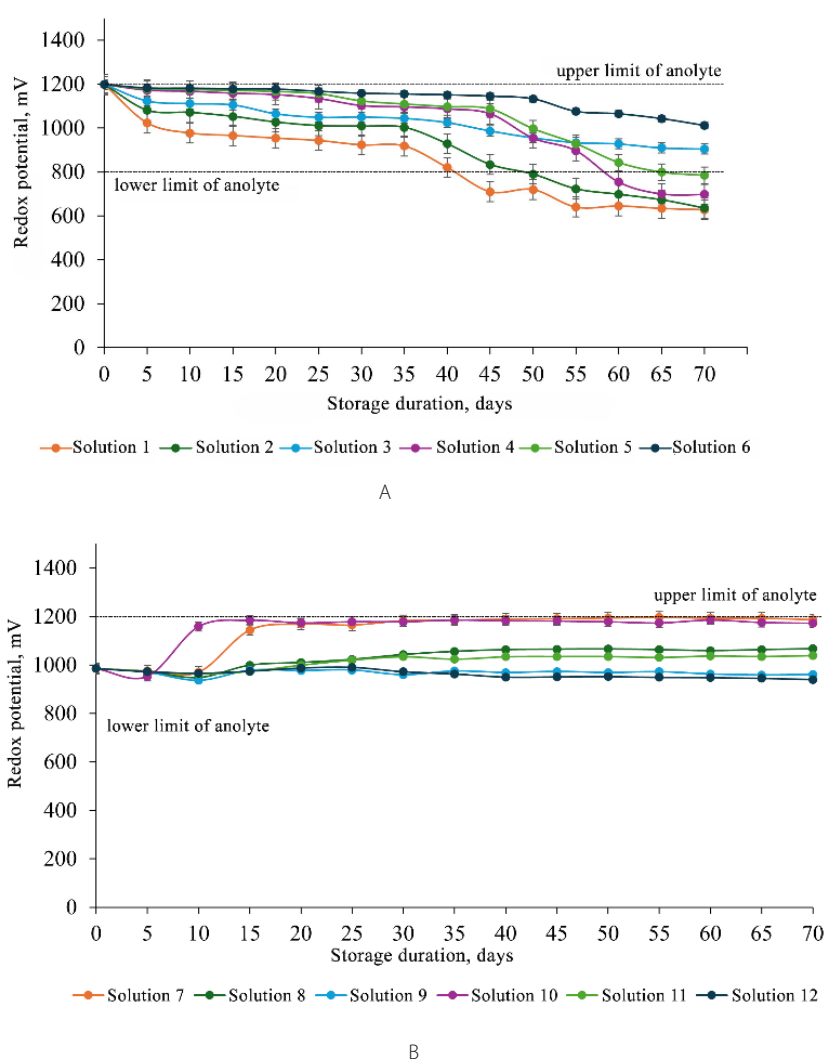
of acidic and neutral analytes: redox potential, pH, active chlorine content, and wetting ability.

Changes in Redox Potential

The redox potential of the acidic analytes (solutions 1–6) stored for 70 days decreased at a rate depending on the storage conditions, as compared to the feed solution (Figure 2A). The decrease was noticeable in the samples stored in polypropylene containers, both in bright and dark rooms at room temperature for 45 days. Their redox potential values amounted to 710 ± 3.7 mV and 808 ± 3.9 mV, respectively, down from the initial value of 1198 ± 5.3 mV. The samples stored in glass and

Figure 2

Redox Potential of Acidic (A) and Neutral (B) Analytes Stored under Different Conditions for 70 Days



polypropylene containers at 4°C for 45 days had redox potential values of 1145 ± 4.9 mV and 987 ± 4.5 mV, respectively. However, the neutral anolyte samples (Figure 2 B) showed no significant decrease in redox potential.

Changes in pH

Changes in pH values in the acidic (A) and neutral (B) electrochemically activated solutions during prolonged storage are shown in Figure 3. The acidic analytes (Figure 3A) had almost the same pH values, regardless of the storage conditions. However, the neutral analytes (Figure

3B) stored in bright and dark rooms at room temperature (solutions 7, 10) had a noticeable decrease in pH, regardless of the packaging material, which stabilized over time. These solutions had a significant decrease in pH on the 20th day of storage, namely from 6.48 ± 0.02 to 2.58 ± 0.10 and from 6.48 ± 0.02 to 2.48 ± 0.11 , respectively.

Changes in the Content of Active Chlorine

Changes in the content of active chlorine in the acidic (A) and neutral (B) electrochemically activated solutions are shown in Figure 4. The acidic analytes (Figure 4A) had a lower content of active chlorine as early as on the first

Figure 3

Acidity (pH) of Acidic (A) and Neutral (B) Analytes Stored under Different Conditions for 70 Days

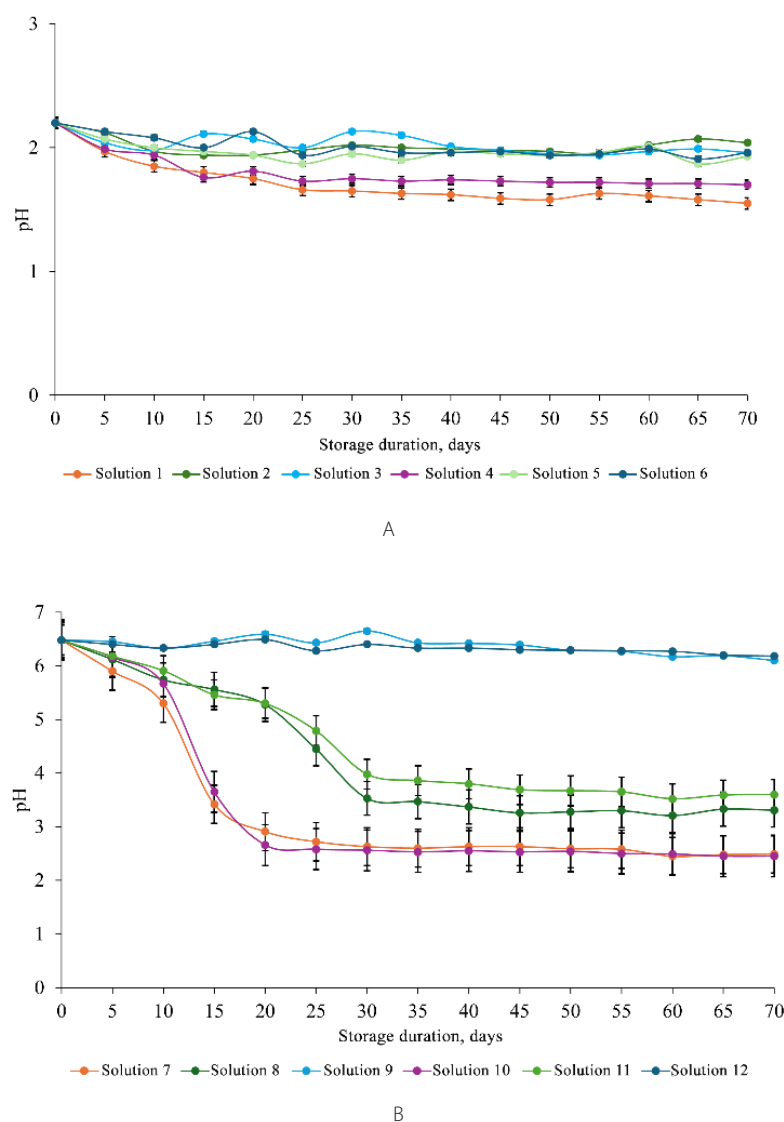
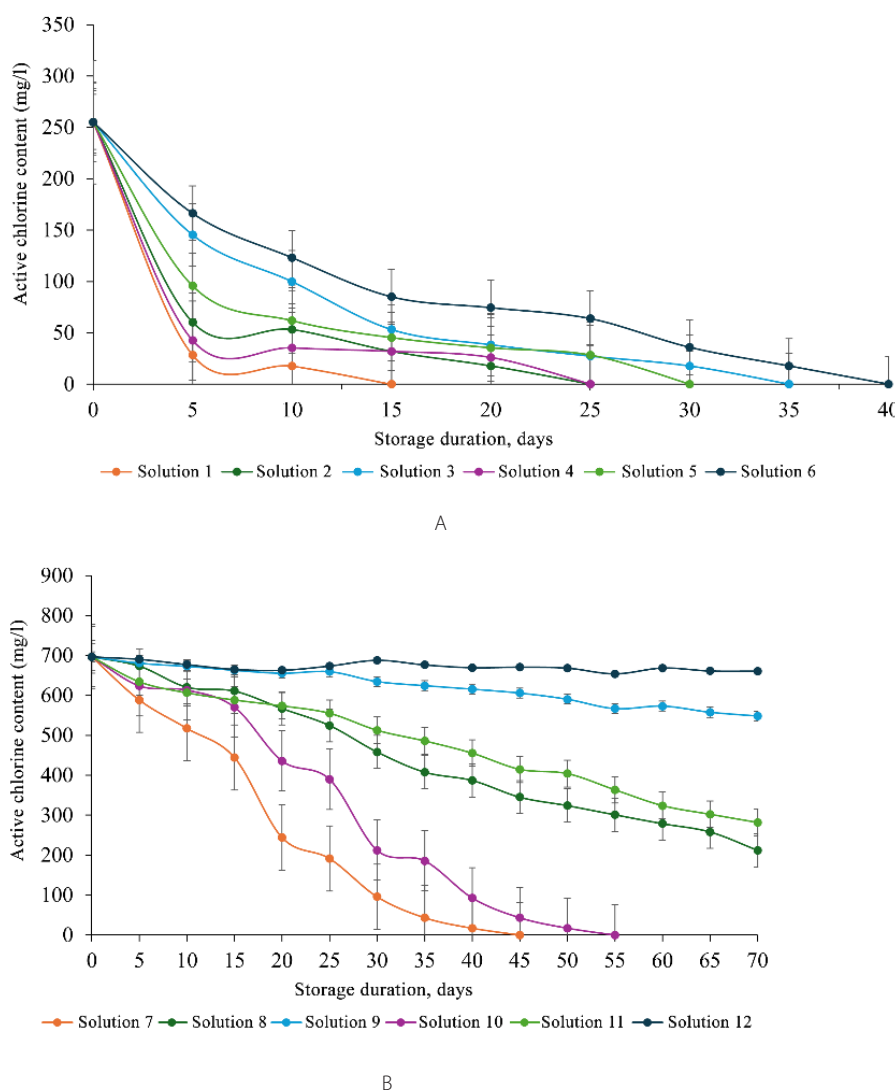


Figure 4

Active Chlorine Content (mg/l) in Acidic (A) and Neutral (B) Analytes Stored under Different Conditions for 70 Days



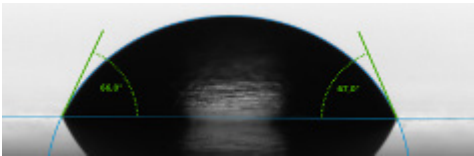
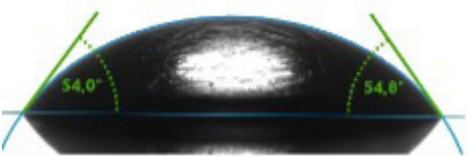
5 days of storage. The time when this indicator reached almost 0 mg/l varied for solutions 1–6 depending on the material and storage conditions, with a maximum time of 40 days. In the neutral analytes (Figure 4B), the content of active chlorine changed depending on the storage conditions. Those stored in a bright room in either plastic or glass containers (solutions 7 and 10) had this indicator decreasing to 0 mg/l in 45 and 55 days, respectively. Those stored in a dark room in both plastic and glass containers (solutions 8 and 11) had their content of active chlorine decreasing by $69.54 \pm 7.86\%$ and $60.80 \pm 7.12\%$, respectively, on the 70th day of storage. In the samples stored at $5 \pm 1^\circ\text{C}$ in both plastic and glass containers

(solutions 9 and 12), the decrease in active chlorine reached $21.33 \pm 4.23\%$ and $5.14 \pm 2.64\%$, respectively, at the end of storage.

Changes in the Wetting Ability of Neutral Analyte

Table 2 shows changes in the contact angle, which characterizes the ability of an adhesive to wet the substrate, a stainless-steel test surface imitating the surface of the equipment. As can be seen, the wetting ability of a freshly prepared solution of neutral analyte (Analyte 1) was $63.75 \pm 2.67^\circ$, while the wetting ability of solution 12 stored in a glass container at $5 \pm 1^\circ\text{C}$ for 70 days (Analyte 2) was $46.03 \pm 2.24^\circ$.

Table 2
The Contact Angle between Different Adhesives and a Stainless-Steel Test Surface

Adhesive	Contact angle on the surface, °
A. Anolyte 1	 63.75 ± 2.67
B. Anolyte 2	 46.03 ± 2.24
C. Hydrochloric acid (0.1 N HCl)	 54.60 ± 2.05
D. Hydrochloric acid (2.0 N HCl)	 27.34 ± 3.67

DISCUSSION

The physicochemical properties of electrochemically activated (ECA) solutions depend on the characteristics of an electrochemical cell where they are produced, as well as on the feed solutions undergoing electrolysis. Solutions obtained from reactions at the anode have proven bactericidal efficacy due to the formation of several active forms of chlorine-containing oxidants such as Cl_2 , HClO , or OCl^- . Such solutions commonly have their redox potential ranging from +800 mV to +1200 mV and a pH value of 2–5. However, hydrogen is formed at the cathode, along with other activated substances (mainly antioxidants), which leads to a decrease in the redox potential and an increase in pH (Thorn, 2012; Manevich, 2024). Cathode solutions (catholytes) can be used as detergents but they fall outside this study. A modified version of acidic ECA solutions can also be obtained by directing part of the anode output back to the cathode chamber, producing a neutral anolyte (Petrova, 2020).

Our data suggest that both temperature and storage material significantly affect the rate of decrease in redox

potential and the content of active chlorine in acidic anolytes, with temperature having a greater effect than storage material on the storage time. Fabrizio and Cutter (2003) also found that acidic anolyte solutions were more stable when stored at 4 °C compared to 25 °C, with their redox potential remaining stable during the first three days. The authors reported that the pH values remained constant throughout prolonged storage in the acidic anolytes, but decreased in the neutral anolytes stored in both light and dark environments at room temperature, regardless of the storage material. This finding was consistent with our results. The decrease in pH was likely due to exposure to ultraviolet radiation. In a dark room with no access to ultraviolet radiation, the pH of solutions 8 and 11 decreased to 3.32 ± 0.12 during 30 days of storage. Yet, solutions 9 and 12 stored in a cold and dark room showed virtually no change in pH over 70 days. These data are not fully consistent with the study of Cui *et al.* (2009), who found that the pH of both neutral and acidic anolytes remained stable over 30 days.

In our study, the ECA solutions showed a greater decrease in redox potential during the first days of storage. The

acidic anolyte solutions stored in polypropylene containers had a somewhat faster decrease than those stored in glass containers. No significant decrease in redox potential was observed in the neutral anolytes, but a certain increase was noted in the samples stored at $5 \pm 1^\circ\text{C}$ (solutions 7 and 10), which stabilized after 15–20 days. Apparently, this factor is associated with the Nernst equation (1), in which temperature is the only term that is not a constant.

$$E = E_0 - \frac{RT}{nF} \cdot \ln \frac{a_{\text{Ox}}}{a_{\text{Red}}}, \quad (1)$$

where a_{Ox} and a_{Red} are the activities of the oxidative and reductive forms of a substance in the electrode reaction, E_0 is the standard electrode potential, R is the gas constant, n is the number of electrons participating in the electrode reaction, and T is the absolute temperature.

Similarly to the changes in redox potential, the lowest rate of decrease in active chlorine was recorded in the samples stored in glass containers at $5 \pm 1^\circ\text{C}$. This finding was consistent with other studies (Len, 2002; Kinigk, 2008). The authors suggested that chlorine loss in closed containers (with no evaporation) was mainly due to its self-decomposition. This can be explained by the formation of chlorine-containing acids in the stored samples, which converted the solutions from a neutral medium to an acidic one. The decomposition of unstable hypochlorous acid into oxygen and hydrogen chloride gradually results in active chlorine interacting with water, with only hydrochloric acid remaining in the solution. This reaction occurs faster in the light¹ (Shestipalov, 2015).

Neutral anolyte solutions are significantly more stable than acidic ones in terms of redox potential and active chlorine under identical storage conditions. Furthermore, neutral anolyte solutions are indifferent to most materials used in dairy enterprises.

Unlike our study, none of the previous studies on acidic and/or neutral ECA solutions considered their wetting ability. We found a decrease in the contact angle for the neutral anolyte during storage. For comparison, we presented the contact angle values for hydrochloric acid (HCl) solutions at different concentrations (0.1 N and 2.0 N), as shown in Table 2 (C, D). Obviously, a higher concentration of this acidic electrolyte improves wettability, which is indicated by a lower contact angle. The contact angle between the anolyte stored for 70 days and a stainless-steel surface was

comparable to the contact angle for the 0.1 N hydrochloric acid solution. The decrease in the contact angle and pH of the anolyte solution is most likely due to a partial association of chlorine-containing acids.

Our results confirmed the expected significant effect of storage conditions on the key physicochemical properties of both acidic and neutral anolytes, with temperature being the most important factor of their stability. Although the illumination of storage rooms or ultraviolet radiation did not have a significant effect on the storage stability of the anolytes, those stored in the dark showed greater stability.

Glass containers proved better for storing ECA solutions compared to plastic containers. ECA solutions of neutral anolytes should be stored in closed glass, stainless steel (chrome-nickel) or enamel (intact) containers in a cool, dark place at $0\text{--}8^\circ\text{C}$, away from heating devices or exposure to direct sunlight, with the principles of product adjacency observed.

Our results were obtained with a number of study limitations. One of them was the use of AQUATRON-17-L and STEL-ANK-SUPER electrolysis units equipped with electrochemical MB reactors with diaphragm elements, as well as MB-11 and MB-26 reactors. With similar modules and electrolysis regimes, this technology can be scaled up from a laboratory unit (5–20 l/h) to an industrial facility (1000 l/h), with a concentration of oxidants increasing from 500 to 5000 mg/l. It is highly probable that ECA anolyte solutions obtained in more productive industrial units will have the same physicochemical properties under appropriate storage conditions. However, alternative regimes and materials of membranes and electrodes in electrochemical reactors cannot guarantee the same stability of ECA solutions.

Another study limitation concerned the aqueous-salt feed solutions subjected to electrolysis. We used aqueous solutions of sodium chloride (table salt) as the most accessible and widespread substance. However, solutions of sodium or potassium salts of various acids, including organic acids, can also be used as feed solutions. The properties of anolytes obtained by electrolyzing these salts are of great scientific interest.

In determining the wetting ability of neutral anolytes by measuring the contact angle, our study was limited by the

¹ Alagezyan, R. (1981). *Detergents and disinfectants in the dairy industry*. M.: Light and Food Industries.

use of stainless-steel plates as a substrate. In wettability studies, substrates are commonly made of glass, plastics, ceramics, and other materials. We chose test surfaces made of austenitic stainless steel of a certain grade to imitate the surfaces of process equipment (95 % of stainless steel) to be treated with the solutions of neutral anolytes.

Finally, our study was limited by the storage time of 70 days, which was due to a complete loss of active chlorine in all acidic solutions and their degradation after 40 days. Therefore, there was no need in comparing the physicochemical properties of acidic and neutral anolytes for more than 70 days.

CONCLUSION

We studied the effect of storage conditions on the physicochemical properties of electrochemically activated solutions of neutral and acidic anolytes to identify the key factors of their stability. Our results showed that while storing acidic anolytes is impractical, neutral anolytes should be stored under certain conditions. The changes in the wetting ability of neutral anolyte solutions during storage confirmed our hypothesis about the association of chlorine-containing acids in the solution. This calls for further research into the corrosive activity of anolytes against various materials subjected to disinfection at food enterprises.

Our results can be used to develop recommendations for applying electrochemically activated solutions in the dairy industry for sanitization purposes. Further research should focus on the bactericidal properties of anolyte solutions with different values of redox potential and active chlorine, as well as a possibility of improving their wetting ability.

CONTRIBUTIONS

Boris V. Manevich: conceptualizing; developing research methodology; working with software; visualizing; conducting the study; writing-reviewing and editing the manuscript.

Evgeniy N. Titov: developing research methodology; working with software; visualization; conducting the study; writing-reviewing and editing the manuscript.

Elena A. Burykina: writing-preparing a draft of a manuscript.

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