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Corrosion resistance of Ever Silver vessel in the presence of rasam-a light South Indian traditional soup

ABSTRACT

Food packaging serves purposes of food product safety and easy handling and transport by preventing chemical contamination and enhancing shelf life, which provides convenience for consumers. Various types of materials, including plastics, glass, metals, and papers and their composites, have been used for food packaging. However, owing to consumers' increased health awareness, the significance of transferring harmful materials from packaging materials into foods is of greater concern. In the present study corrosion resistance of Ever Silver vessel in the absence and presence of rasam recipe, a light South Indian traditional soup made with basic spices, ripe tomatoes, tamarind and herbs. AC impedance spectra have been used to measure the corrosion resistance. It is observed that the corrosion resistance of Ever Silver vessel increases in the presence of rasam recipe. This is due to the presence of various molecules present in the ingredients of rasam. So it is concluded that rasam recipe can be stored in Ever Silver vessel and also rasam can be served in Ever Silver vessel during dining.

Keywords: *Corrosion resistance, Ever Silver vessel, rasam, AC impedance spectra, electrochemical study*

1. INTRODUCTION

Food packaging systems have been widely studied [1-13].

Food packaging is a packaging system specifically designed for food and represents one of the most important aspects among the processes involved in the food industry, as it provides protection from chemical, biological and physical alterations [1]. The main goal of food packaging is to provide a practical means of protecting and delivering food goods at a reasonable cost while meeting the needs and expectations of both consumers and industries [1]. Additionally, current trends like sustainability, environmental impact reduction, and shelf-life extension have gradually become among the most important aspects in designing a packaging system [2].

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History

Packaging of food products has seen a vast transformation in technology usage and application from the Stone Age to the industrial revolution:

Year	Description	Ref.
7000 BC	The adoption of pottery and glass which saw industrialization around 1500 BC.	[3]
1700s	The first manufacturing production of tinplate was introduced in England (1699) and in France (1720). Afterwards, the Dutch navy start to use such packaging to prolong the preservation of food products.[4]	[4]
1804	Nicolas Appert, in response to inquiries into extending the shelf life of food for the French Army, employed glass bottles along with thermal food treatment. Glass has been replaced by metal cans in this application. However, there is still an ongoing debate about who first introduced the use of tinplates as food packaging.	[4],5]

1870	The use of paper board was launched and corrugated materials patented.	[6]
1880s	First cereal packaged in a folding box by Quaker Oats.	[7]
1890s	The crown cap for glass bottles was patented by William Painter.	[8]
1950s	The bag-in-box system was invented by American chemist William R. Scholle – initially for acid liquids, but quickly also used for food liquids.	
1960s	Development of the two-piece drawn and wall-ironed. Metal cans in the US, along with the ring-pull opener and the Tetra Brik Aseptic carton package.	[9]
1970s	The barcode system was introduced in the retail and manufacturing industry. PET plastic blow-mold bottle technology, which is widely used in the beverage industry, was introduced.	[10]
1990s	The application of digital printing on food packages became widely adopted.	
	Plastic packaging saw its inaugural use during World War II, even though materials employed in its manufacturing (such as cellulose nitrate, styrene and vinyl chloride) were discovered in the 1800s.	[11]

Food packaging alloys

There are several metals which have been used as food packaging materials including; aluminum (Al), stannous or tin (Sn), Sn free steel (SFS), and rustles steel (RS) commonly known as stainless steel. These metals provide hard food packaging such as cans and flexible food packaging in the form of foil and bags.

Various metals are commonly used in food packaging. Here are the main ones:

1. *Aluminum:*Aluminum is widely used for food packaging. It's used to make cans, as well as thin aluminum foils and coatings. Aluminum packaging is lightweight, corrosion-resistant, and easily recyclable.
2. *Steel:* Steel is primarily used to make rigid cans. These steel cans are commonly used for packaging food items. Steel cans are durable and provide good protection for the contents.
3. *Tinplate:* Tinplate, also known as tin-coated steel or electrolytic chromium-coated steel, is another metal used in food packaging. It's often used for items like cans and lids. Direct contact between the metal and food can be prevented by coating the metal with an organic polymer to maintain packaging integrity and food properties.
4. *Stainless Steel:* While less common, stainless steel is sometimes used for specific food packaging applications. It offers excellent durability and resistance to corrosion.

These metals play a crucial role in preserving food quality, safety, and shelf life.

Rasam recipe

Rasam is a light South Indian traditional soup made with basic spices, ripe tomatoes, tamarind and herbs. It is very soothing to the tummy and helps in digestion.Usually rasam recipe is kept in Ever Silver vessel and served Figure 1.The present work is undertaken to investigate the corrosion resistance of Ever Silver vessel in the absence and presence of rasam recipe. The corrosion resistance is measured by AC impedance spectra.

Figure 1 .Rasam RecipeinEver Silver vessel

2. EXPERIMENTAL METHOD

Ever SilverComposition

Ever Silveris an alloy of silver that consists of 92.5% pure silver and and 7.5% other metal, usually copper. The other metals in the alloy increase hardness, so the material will be durable**.** Ever silver was purchased in the vessel marts**.**

Preparationofrasamrecipe

The recipe was prepared in the usual way. Rasam a soup of spices is a traditional South Inian Food. It is traditionally prepared using tamarind juice as a base with the addition of Indian seasame oil, turmeric, tomato, chilly, pepper, garlic, cumin, curry leaves, mustard, coriander, asafoetida, sea salt and water. There are many ingredients such as tartaric acid, curcumin and many vitamins and amino acids present in the rasam soup

Electrochemicalstudy

ACimpedancespectra

A three-electrode cell assembly was used to record AC impedance spectra. Wehave taken the

various test solutions like water and rasamin Ever Silver. AC impedance spectral studies were carried out in aCHI – Electrochemical works tation with impedance. The corrosion resistance of Ever Silver electrode immersed in various test solutions have been measured. A three – electrode cell assembly was used. The working electrode was Ever Silver electrode. A saturated calomel electrode (SCE) was the reference electrode and platinum was the counter electrode (Figure 2).

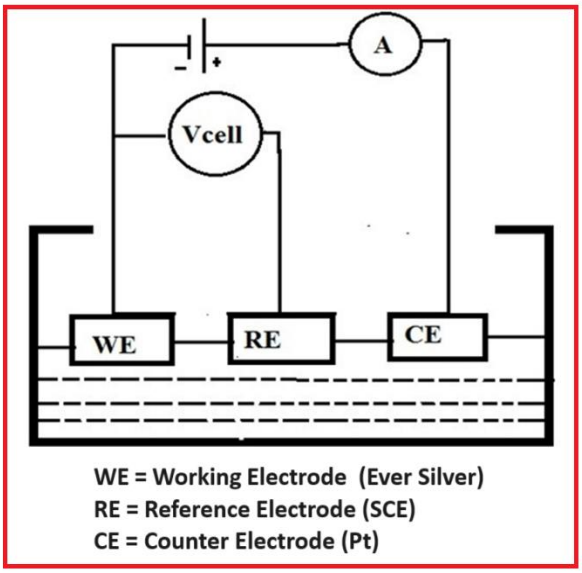

Figure 2. Three-electrode cell assembly

The real part (Z') and imaginary part (-Z'') of the cell impedance were measured in ohms at various frequencies.Values of the charge transfer resistance (R_t) and the double layer capacitance (C_{dl}) , impedance value and phase angle were calculated from Nyquist plots and Bode plots.

3. RESULTS AND DISCUSSION

Ever Silver is popularly used for cookware, kitchen utensils and cutlery. Thisis because it is hardwearing, corrosion resistant and it doesnot affect the flavour of the food when used for food storage or production. Due to the resistance levels, foods with high acidity will not cause damage. Usually, students take many varieties rice and interesting recipes in stainless steel. In this project we have taken water and rasam recipe in a stainless steel to identify whether Ever Silverundergoes corrosion or not. We have undertaken AC impedance spectra study. They have been employed to investigate the corrosion resistance of Ever Silver electrode when it is immersed in various test solutions like water and rasam recipe.

Analysis of results of AC impedance Spectra [Electrochemical Impedance

Spectra (EIS)]

AC impedance spectra have been used to detect the formation of the film formed on the metal surface. If a protective film is formed, the charges transfer resistance (R_t) increases, impedance value increases, phase angle value increases and double layer capacitance (C_{dl}) value decreases.

The AC Impedance spectra of Ever silver electrode immersed in various solutions are shown in Figures 4, 5 (Nyquist), Figures 6, 7 (Bode plots) and Figures 8, 9 (Interactive 3D plot-log freq). The corrosion parameters are compared in Figure 10.

The AC Impedance parameters, namely, charge transfer resistance (R_t), impedance value, phase angle value and double layer capacitance (C_{dl}) are given in Table 1.

Table 1. Corrosion parameters of Ever Silver electrode immersed in various test solutions, obtained from AC Impedance spectra

System	R_t, Ohm.cm^2	C_{dl}, F/cm^2	Impedance Log (Z/Ohm)	Phaseangle^o
Water	9.96	5.12×10^{-7}	1.518	0.1036
Rasam	47.10	1.08×10^{-7}	1.905	4.773
Observation	increases	decreases	increases	increases
Inference	Corrosion resistance increases	Corrosion resistance increases	Corrosion resistance increases	Corrosion resistance increases
Implication	Rasam recipe can be stored in Ever Silver vessels without any hesitation			

Letusrecollect the principles of Acimpedance spectra and corrosion inhibition study.

"Ifaprotective film is formed on the metal surface ,thecharges transfer resistance (R_t) increases, impedance value increases, phase angle value increases and double layer capacitance (C_{dl}) value decreases" (Figure 3).

Interesting conclusions are derived from Table1. When Ever Silver electrode is immersed in water, the charge transfer resistance (R_t) is 9.96 Ohm.cm^2. Double layer capacitance (C_{dl})value is 5.12×10^{-7} F/cm^2.

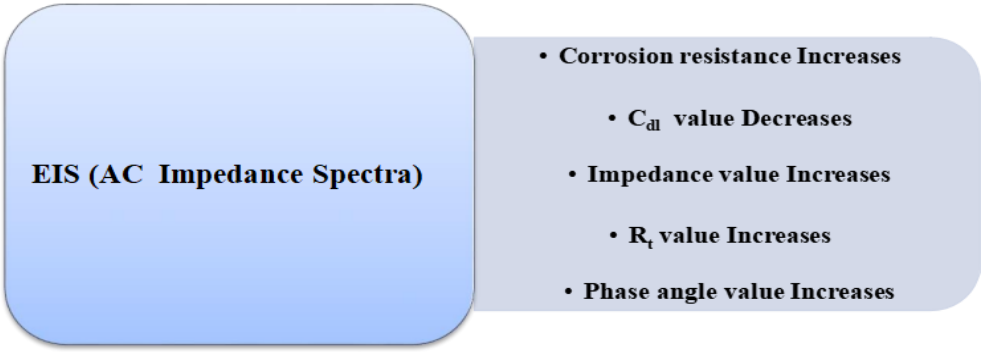

Figure 3. Correlation among corrosion parameters of AC impedance spectra

Interesting conclusions are derived from Table1. When Ever Silver electrode is immersed in water, the charge transfer resistance (R_t) is 9.96 Ohm.cm^2. Double layer capacitance (C_{dl})value is5.12×10^{-7}F/cm^2.

When Ever Silver electrode is immersed in rasam system, the corrosion resistance of Ever Silver electrode increases. This is due to the adsorption of molecules of the ingredients present in rasam system. When Ever Silver is electrode immersed in rasam system the charge transfer resistance (R_t) increases to 47.103 Ohm.cm^2. Double layer capacitance (C_{dl}) value decreases to is1.0827×10^{-7}F/cm^2. Impedance value increases to 3.217 and phase angle increases to 5.678º.

When Ever silver electrode is immersed in rasamsystem , the corrosion resistance ofEver silver electrode increases. This is due to the presence of molecules of the incredients introduced by the rasam system.

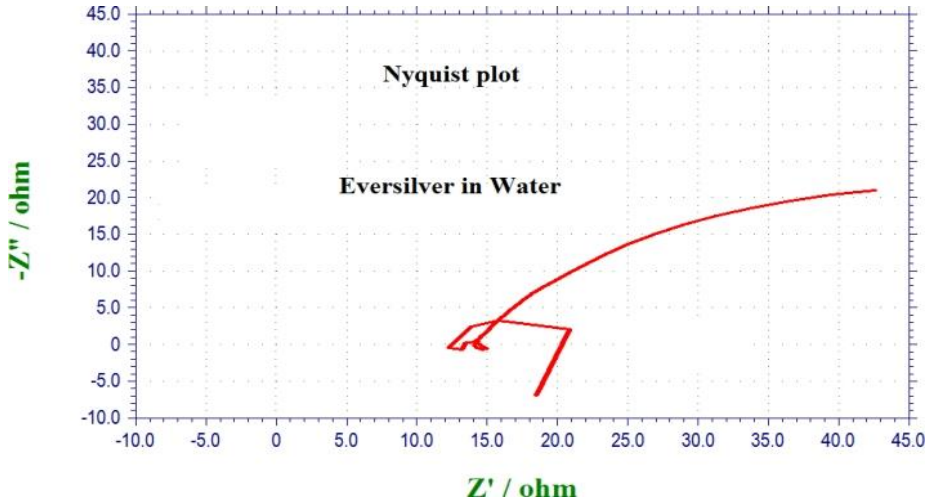

Figure 4. Nyquist plot of Ever Silver electrode immersed in Water

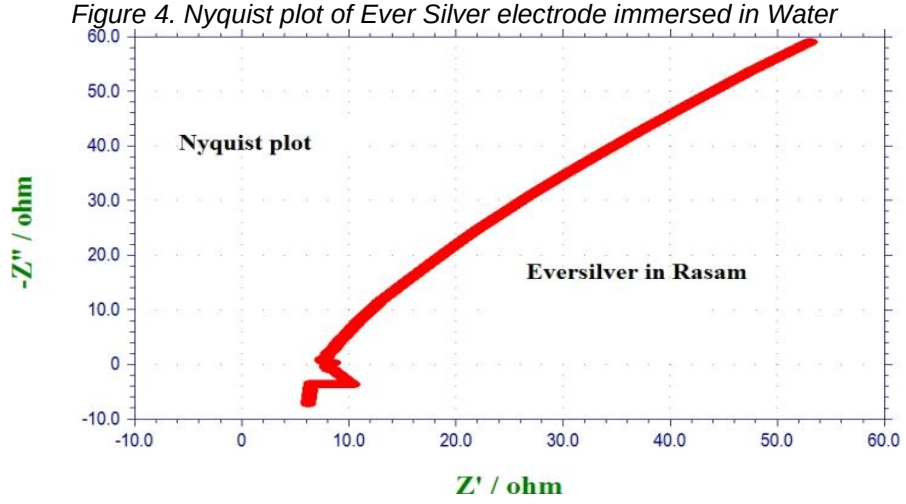

Figure 5. Nyquist plot Ever Silver electrode immersed in Rasam system

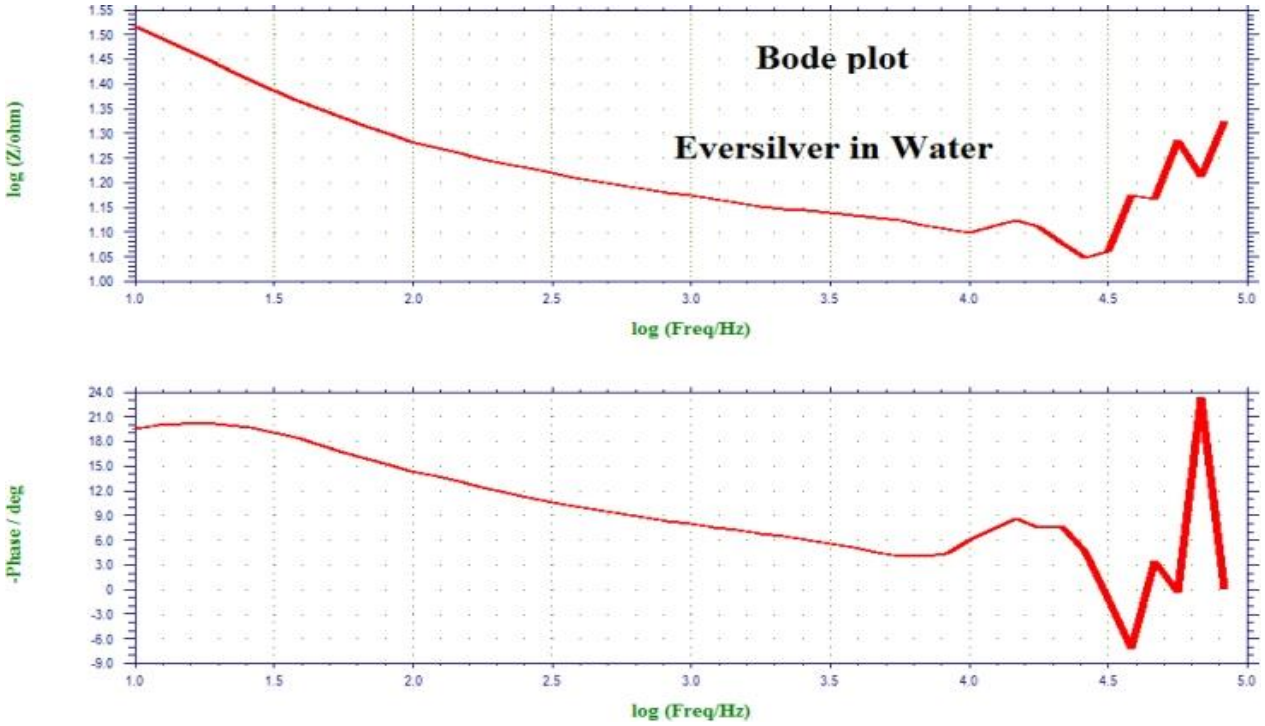

Figure 6. Bode plot of Ever Silve relectrode immersed in Water

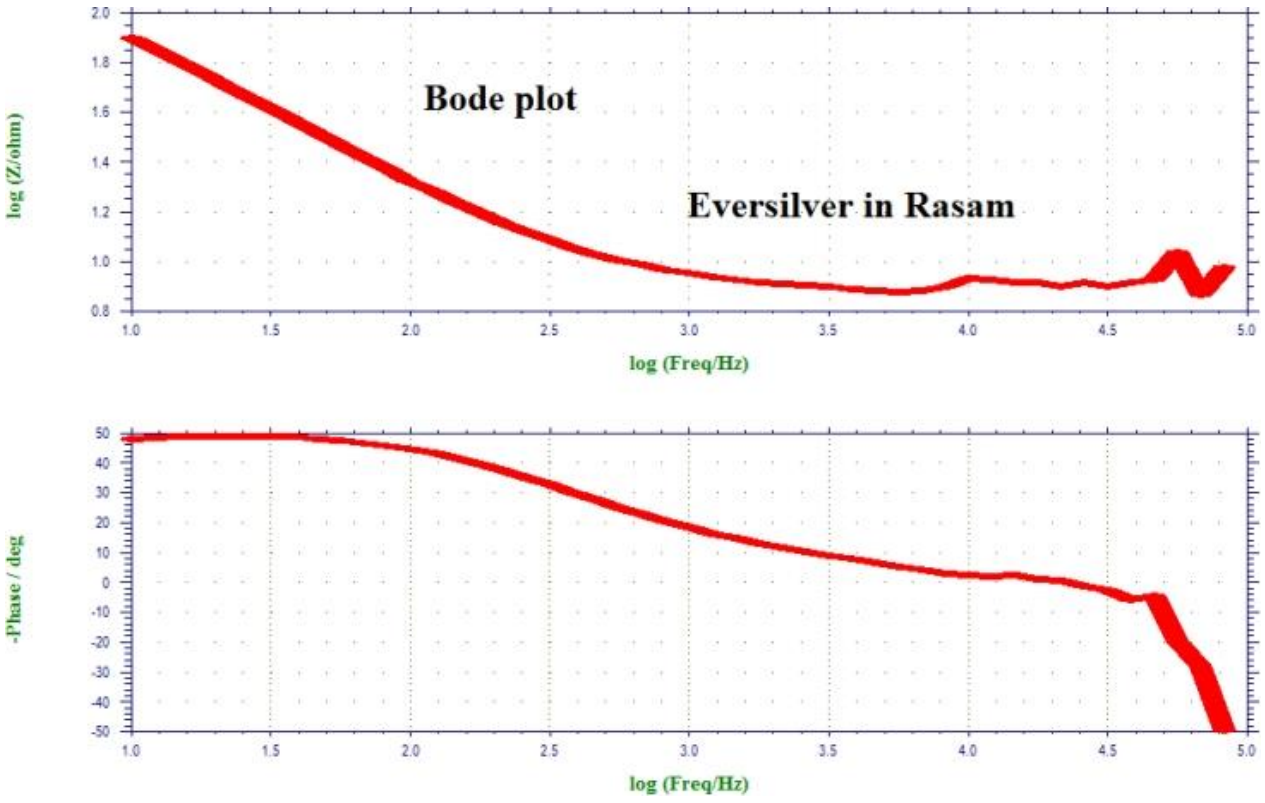

Figure 7. Bode plots Ever Silver electrode immersedin Rasam system

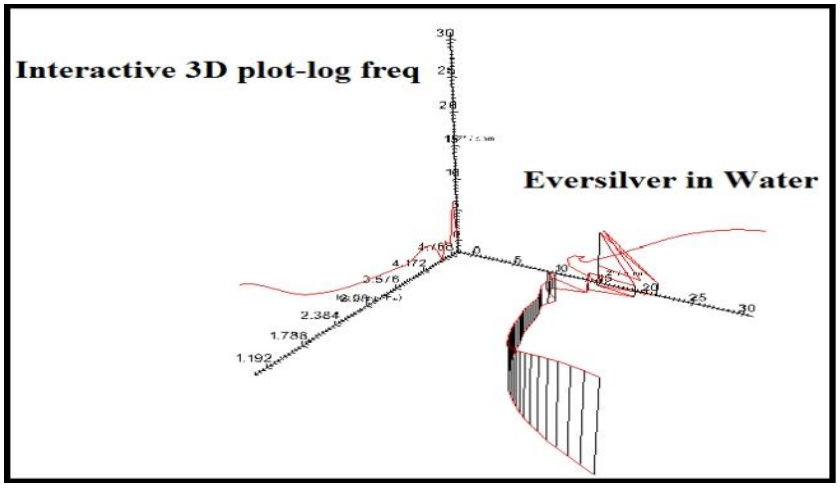

Figure 8. Interactive 3D plot-log frequency of Ever Silver electrode immersed in Water

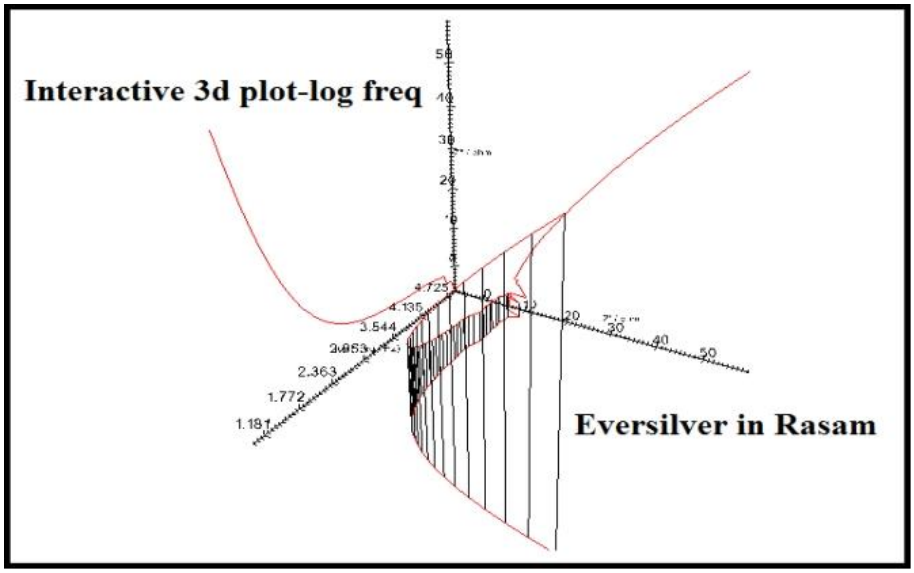

Figure 9. Interactive 3D plot-log of Ever Silver electrode immersed in Rasam system

Implication

Corrosion resistance of Ever Silvervessel increases, when it comes in contact with rasam system . This conclusion is drawn when compared with water system used.

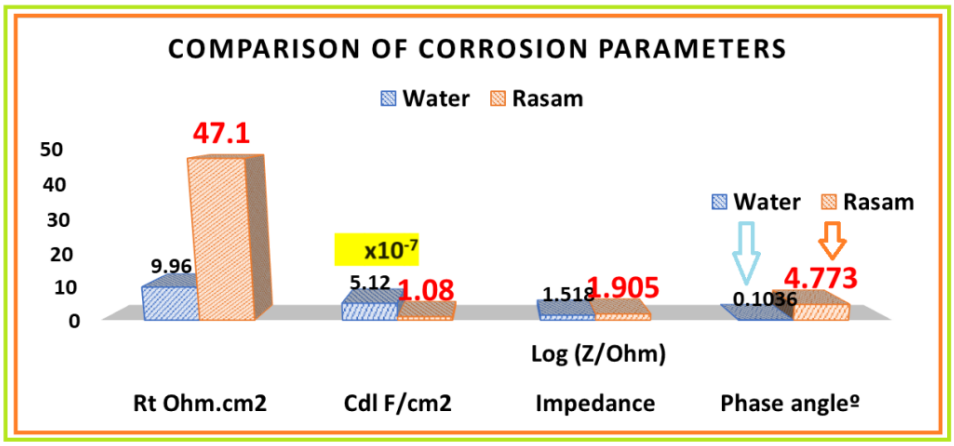

Figure 10. Comparison of corrosion parameters

4. CONCLUSION

This project is undertaken to know ifEver Silver vessels undergo corrosion or not, when they come in contact with some food items (recipes).

AC impedance spectra have been employed to investigate the corrosion resistance of Ever Silver electrode when it is immersed in various test solutions like water and also rasam recipe.

If a protective film is formed, the charge transfer resistance increases, impedance value increases, phase angle value increases and double layer capacitance (C_{dl}) value decreases.

When Ever Silver electrode is immersed in rasamsystem, the corrosion resistance ofEver Silver electrode increases. This is due to the presence of molecules of the ingredients introduced into the rasam system. The active ingredients are adsorbed on the metal surface.

The corrosion resistance decreases in the following order:

rasam recipe>water

Scope for furthe rstudies

The present work is undertaken to investigate the corrosion inhibition of Ever Silver inthe presence of water, and rasam recipe. The corrosion resistance has been evaluated by electrochemical study such as AC impedance spectra.

In future the following studies can be under taken

Instead of rasam other food item such as sambar recipe etc., can beused.

Instead of Ever Silver other metals can be used.

Surface analysis such as AFM, EDAX, contact angle etc., can beem ployed.

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IZVOD

OTPORNOST NA KOROZIJU POSUDE EVER SILVER U PRISUSTVU RASAMA – LAGANE JUŽNOINDIJSKE TRADICIONALNE SUPE

Ambalaža za hranu služi u svrhu bezbednosti prehrambenih proizvoda i lako grukovanja i transporta sprečavajući hemijsku kontaminaciju i produžavajući rok trajanja, što pruža pogodnost za potrošače. Za pakovanje hrane korišćene su različite vrste materijala, uključujući plastiku, staklo, metale i papire i njihove kompozite. Međutim, zbog povećane zdravstvene svesti potrošača, značaj prenošenja štetnih materijala iz materijala za pakovanje u hranu izaziva veću zabrinutost. U ovoj studiji otpornost na koroziju posude Ever Silver u odsustvu i prisustvu recepta za rasam, lagane južno indijske tradicionalne supe napravljene od osnovnih začina, zrelog paradajza, tamarinda i začinskog bilja. Spektri impedanse naizmenične struje korišćeni su za merenje otpornosti na koroziju. Primećeno je da se otpornost na koroziju Ever Silver posude povećava u prisustvu rasam recepture. To je zbog prisustva različitih molekula prisutnih u sastojcima rasama.Tako se zaključuje da se recept za rasam može čuvati u Ever Silver posudi, a takođe se rasam može poslužiti u Ever Silver posudi tokom večere.

Ključne reči: *otpornost na koroziju, Ever Silver posuda, rasam, AC impedansni spektri, elektrohemijska studija*

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