JAP&T TPA-Timişoara

Available online at http://journal-of-agroalimentary.ro

Journal of Agroalimentary Processes and Technologies 2020, *26*(1), 22-25

Journal of Agroalimentary Processes and Technologies

AISI 430 stainless steel behavior in neoseptal biocide

Alina-Mihaela Cantaragiu[1], Maricica Stoica[1*], Mariana Carmelia Bălănică Dragomir[1], Cristian Munteniță[1], Ecaterina Daniela Zeca[1], Angela Stela Ivan[1]

[1] *"Dunarea de Jos" University of Galati, 47 Domneasca St, 800008-Galati, Romania*

Abstract

The AISI 430 ferritic stainless steel was immersed into Neoseptal biocide solution for 480 minutes exposure time at room temperature, and then investigated by Scanning Electron Microscopy. Neoseptal biocide is approved for use in food equipment disinfection, as it is based on hydrogen peroxide, with an action time of 30 minutes. Some researchers consider the residual biocide in the food processing lines between the production batches is a sentinel against undesirable microorganisms. On the other hand, the residual biocide can negatively impact stainless steel surfaces via corrosion. Microscopic analysis showed that the residual Neoseptal biocide is more destructive on ferritic stainless steel surfaces, after 480 minutes than after 30 minutes of exposure time.

Keywords: Ferritic stainless steel, biocide, Scanning Electron Microscopy

1. Introduction

Stainless steels play a significant role in the development of different food equipment, and are classified as austenitic, duplex, ferritic, martensitic, and super-austenitic grades [1-4]. Austenitic stainless steels are frequently used in food processing lines due to their good resistance to the different electrolytic media (technological fluids, acidic/alkaline agents, excessive humidity etc.), cleanability, durability, and electrochemical inertia [5]. However, they have been progressively replaced by ferritic stainless steels due to their low cost (the latter contain only small quantities of nickel), and aesthetic quality [3, 6-8].

In the food industry equipment disinfection is an essential stage in preventing the microbial contamination of foods [8, 9]. In this context, some researchers consider that the remaining biocide in the food processing lines between the production batches works on as guard against undesirable microorganisms [5, 8, 10].

On the other hand, other researchers have shown that the residual biocide can have a significant influence on stainless steel equipment surfaces *via* corrosion [8, 11-13].

Hydrogen peroxide (H_2O_2) is a commonly used biocide, effective against all forms of microorganisms at lower pH, low concentrations, used in the food/beverage disinfection process.

However, 2% hydrogen peroxide formulations alone may not be compatible with many types of materials [14]. The aim of this study is to examine, by means of Scanning Electron Microscopy (SEM), the AISI 430 ferritic stainless steel surfaces exposed to the Neoseptal biocide for longer contact time (480 minutes).

2. Materials and Method

2.1. *Materials*

2.1.1. Neoseptal biocide: Neoseptal is approved by the Romanian National Register of Biocide Products to be used in the food industry [15]. Neoseptal is very fast-acting, especially at low concentrations and room temperature. The action time for this biocide is 30 minutes. Neoseptal was manufactured by Dr. Weigert (Germany), being based on 30 wt% of H_2O_2. The tests were performed with Neoseptal of 2% *sln.* (the working concentration established by the suppliers), prepared in distilled water; the solution pH was 3.2, its conductivity was 550 μS/cm.

Corresponding authors: adirivis@yahoo.com

*2.1.2. AISI 430 ferritic stainless steel***:** Tests were performed using AISI 430 ferritic stainless steel. The stainless steel was mechanically press-cut into coupons, each 20 x 10 x 2 mm in size. All ferritic stainless steel coupons were chemically cleaned to eliminate any fat-based substances [1, 5, 16, 17], and stored in moisture-free desiccators prior to use. The stainless steel coupons were exposed to the test Neoseptal biocide solution for 30 and 480 minutes exposure time, at room temperature.

2.2. Method

2.2.1. Scanning Electron Microscopy: After the contact time with the biocide, the AISI 430 stainless steel surfaces were investigated by SEM using a high-magnification Quanta 200 (Philips) device. All SEM investigations were performed according to previously described protocols and setups [18]. Only at the end of the experiment, the investigated areas (20 fields 50 μm^2 in area for each coupon) were increased to verify the general view of the sample.

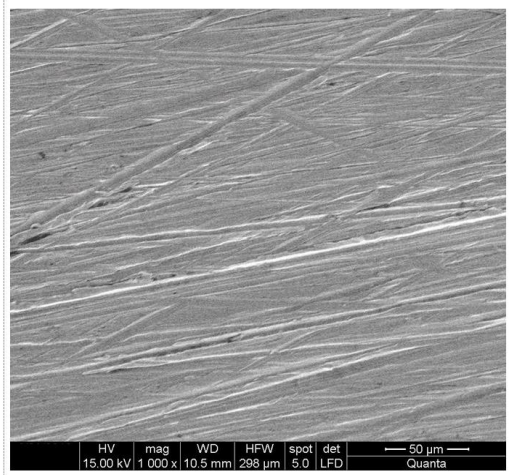
3. Results and Discussion

3.1. Results

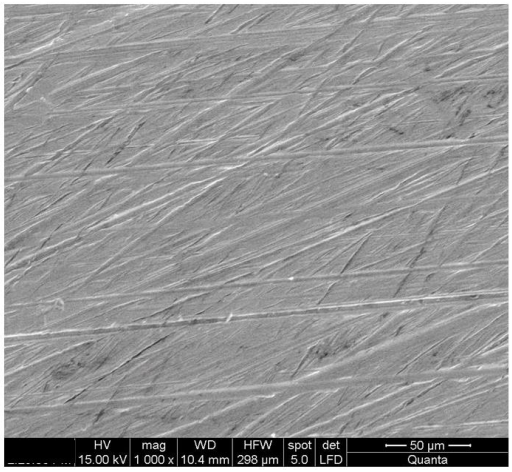
The results of this study are shown in Figures 1a, 1b, and 2a, 2b.

Figures 1a and 1b show the micrographs of the metallic surfaces exposed to the distilled water (a), and to the test Neoseptal biocide solution (b) at room temperature for 30 minutes.

Figures 2a and 2b show the micrographs of the metallic surfaces exposed to distilled water (a), and to the test Neoseptal biocide solution (b) at room temperature for 480 minutes.

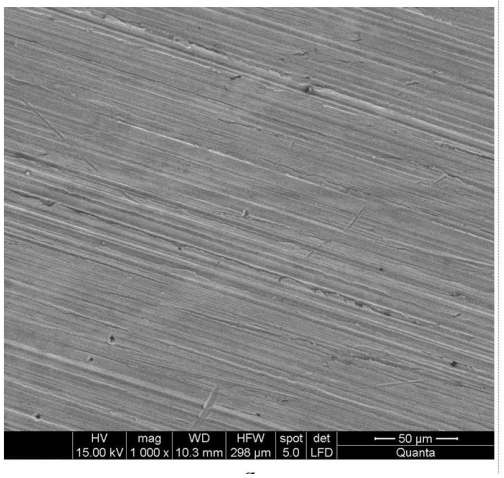


(a)

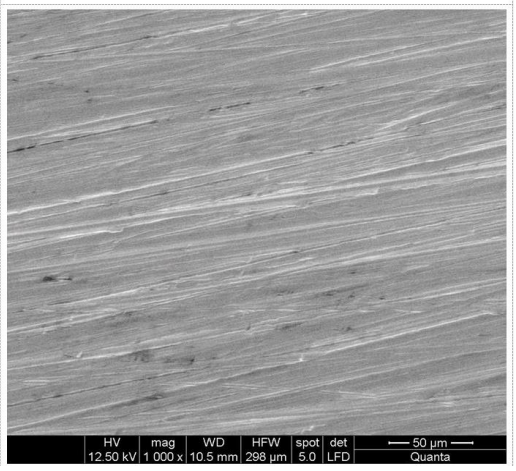


(b)

Figure 1. SEM images of AISI 430 ferritic stainless steel surfaces exposed to distilled water (a), and to the test Neoseptal biocide solution (b) at room temperature for 30 min.



(a)



(b)

Figure 2. SEM images of AISI 430 ferritic stainless steel surfaces exposed to distilled water (a), and to the test Neoseptal biocide solution (b) at room temperature for 480 min.

3.2. Discussion

Each AISI 430 ferritic stainless steel coupon was evaluated by high-magnification SEM in order to detect possible modifications (Figures 1a, 1b, and 2a, 2b).

Figure 1 reveals some differences between the stainless steel surfaces immersed into distilled water at room temperature for 30 minutes (Figure 1a), and into the Neoseptal biocide solution at room temperature for 30 minutes (Figure 1b). Figure 1a shows that the AISI 430 stainless steel surface exposed to the distilled water has a roughness (series of fells and valleys, which vary both in height and spacing) and pit-free appearance. Figure 1b illustrates that the AISI 430 ferritic stainless steel sample exposed to the Neoseptal biocide solution at room temperature for 30 minutes has little dark spots, and pit-free surface (no damaged regions). In addition, a slight levelling of the stainless steel surface can be noticed. No clear pits of corrosion are observed on the stainless steel surface after exposure to the Neoseptal (Figure 1b). This suggests that the AISI 430 ferritic stainless steel is stable to the Neoseptal chemical attack for the time of action (30 minutes) suggested by the manufacturer.

Figure 2 reveals significant differences between the stainless steel surfaces immersed into distilled water at room temperature for 480 minutes (Figure 2a), and into the Neoseptal biocide solution at room temperature for 480 minutes (Figure 2b). As seen in Figure 2a, at room temperature after 480 minutes exposure time, the distilled water induced a passivation process, and the steel surface seems to be protected (the passive layer is formed). On the other hand, Figure 2b shows considerable surface modification after 480 minutes, i.e. after longer contact time with the Neoseptal biocide solution. Neoseptal as a strong oxidant even at very small concentrations increases the corrosion potential, decreases the passivation of stainless steel and results in the destruction of the passive film (Figure 2b) [8, 19]. The acidic environment can produce some breaches in the protective layer [5, 20]. An accentuated levelling of the surface (dissolution reaction) is observed, resulting from the action of the acidic environment, and the pitting potential is likely to increase. The 2% Neoseptal biocide formulation attacks the AISI 430 ferritic stainless steel surface in a uniform manner (Figure 2b).

4. Conclusions

The AISI 430 stainless steel was exposed to the Neoseptal biocide solution and its surface topography was investigated by Scanning Electron Microscopy.

The Scanning Electron Microscopy investigation showed that the 2% Neoseptal biocide formulation is more destructive for ferritic stainless steel surfaces, after longer exposure time.

The Neoseptal biocide remaining in food processing lines between the production batches can potentially decrease the life-time of the food processing line made of ferritic stainless steel on account of a uniform chemical attack.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

References

1. Stoica, M.; Cârâc, G.; Tofan, C.; Constantin, O.E.; Enache, G., Effect of fungal suspensions in NaDCC disinfectant on the corrosion behaviour AISI 304 stainless steel, *Journal of Agroalimentary Processes and Technologies* **2009**, *15*(4), 543-546.
2. Stoica, M.; Brumă, M.; Cârâc, G., Electrochemical study of AISI 304 stainless steel during the exposure at the disinfectant solutions with fungal suspensions, *Materials and Corrosion* 2010, *61*(12), 1017-1025.
3. Dewangan, A.K.; Patel, A.D.; Bhadania, A.G., Stainless Steel for Dairy and Food Industry: A Review, *Journal of Material Sciences & Engineering* **2015**, *4*(5), 191-194, doi:10.4172/2169-0022.1000191.
4. Galié, S.; García-Gutiérrez, C.; Miguélez, E.M.; Villar. C.J.; Lombó, F., Biofilms in the Food Industry: Health Aspects and Control Methods, *Frontiers in Microbiology* **2018**, *9*, 898-915, doi: 10.3389/fmicb.2018.00898.
5. Stoica, M.; Cârâc, G.; Cantaragiu, A.; Apetrei, C., Electrochemical study of stainless steel surfaces in biodegradable biocides, *Journal of Optoelectronics and Advanced Materials* **2010**, *12*(4), 919-922.
6. Sabioni, A.C.S.; Huntz, A.M.; Luz, E.C.; Mantel, M.; Haut C., Comparative study of high temperature oxidation behaviour in AISI 304 and AISI 439 stainless steels, *Materials Research* **2003**, *6*(2), 179-185.

7. Foged, J.N.; Folkmar Andersen, J.; Jepsen, E.; Lovstad, P.; Melsing, E.; Napper, D.; Riis, A.; Jorgensen, C.; Christiansen, P.; Ranlov, P.; Boye-Moller, A.R., Guideline no. 4 – Stainless steel in the food industry – an introduction. Danish Technological Institute, version 1.0 Replacing version "Ny", 2005, pp. 26.
8. Brumă, M.; Stoica, M.; Cârâc, C.; Alexe P., AISI 430 stainless steel behaviour at different disinfectants, *Romanian Journal of Food Science* **2011**, *1*(1), 39-44.
9. Gram, L.; Bagge-Ravn, D.; Yin, Ng.Y.; Gymoese, P.; Fonnesbech, Voge B., Influence of food soiling matrix on cleaning and disinfection efficiency on surface attached *Listeria monocytogenes*, *Food Control* **2007**, *18*, 1165-1171.
10. Leveau, J.Y.; Bouix M., *Nettoyage, désinfection et hygiène dans les bio-industries*. Lavoisier Tec & Doc, Paris, 1999, 548.
11. Masurovsky, E.B.; Jordan, W.K., Studies on the relative bacterial cleanability of milk-contact surfaces, *Journal of Dairy Science* **1958**, *41*(10), 1342-1358.
12. Holah, J.T.; Thorpe, R.H., Cleanability in relation to bacterial retention on unused and abraded domestic sink materials, *Journal of Applied Bacteriology* **1990**, *69*(4), 599-608.
13. Leclerq-Perlat, M-N.; Lalande, M., Cleanability in relation to surface chemical composition and surface finishing of some materials commonly used in food industries, *Journal of Food Engineering* **1994**, *23*(4), 501-517.
14. McDonnell, G., The Use of Hydrogen Peroxide for Disinfection and Sterilization Applications. PATAI'S Chemistry of Functional Groups, **2014**, 1–34. doi:10.1002/9780470682531.pat0885.
15. Government Decision No. 545/2008 amending and completing Government Decision No. 956/2005 concerning the market placing of biocide products, *Official Gazette of Romania* **2008**, *1*(416).
16. Boulangé-Petermann, L., *Pitture e Vernici European* coatings **1997**, *73*, 19.
17. Compère, C.; Bellon-Fontaine, M.N.; Bertrand, P.; Costa, D.; Marcus, P.; Poleunis, C.; Pradier, C.M.; Walls, M.G., Kinetics of conditioning layer formation on stainless steel immersed in sea-water, *Biofouling* **2001**, *17*(2), 129-145.
18. Ishak, H.M.; Misbahul Amin, M.; Mohd Nazaree, D., **2008**, *19*(2), 137.
19. Stoica, M.; Mikoliūnaitė, L.; Ramanavičienė, A.; Alexe, P.; Carac, G.; Dinica, R.; Voronovic, J.; Ramanavičius, A., Corrosion study of stainless steel incubated in solutions consisting of biocide (Oxonia-Active®) and Aspergillus niger suspension, *Chemija* **2012**, *23*(3), 180-186.
20. Schiff, N.; Dalard, F.; Lissac, M.; Morgon, L.; Grosgogeat, B., Corrosion resistance of three orthodontic brackets: a comparative study of three fluoride mouthwashes, *Eur J Orthod*. **2005**, *27*(6), 541-549. doi: 10.1093/ejo/cji050.