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SiC-BASED NANOCOMPOSITES FOR COATING APPLICATIONS INVOLVING WEAR AND CORROSION RESISTANCE[1]

NANOCOMPÓSITOS À BASE DE SiC PARA APLICAÇÕES EM REVESTIMENTOS ENVOLVENDO RESISTÊNCIA AO DESGASTE E A CORROSÃO

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ABSTRACT

Nanocomposites containing SiC as the nano-reinforcement have been widely used in various fields, such as aerospace, automotive, military, and marine industries. In materials engineering, wear and corrosion are two common problems for several applications. Thus, the effects of adding SiC nanoparticles to composites have been studied to improve their physical-chemical and mechanical properties, such as corrosion and wear resistance. In this context, this paper aims to overview the current investigations on nanocomposites containing SiC nanoparticles as the reinforcement, and with focus on application as a coating involving wear and corrosion resistance. The research was carried out in the ScienceDirect and Web of Science databases, where the papers were selected using the descriptors *'ceramic reinforcement', 'nanocomposite', 'coating', 'SiC', 'silicon carbide', 'wear resistance', 'corrosion resistance'* and *'applications'*. From this review, 17 scientific articles were found from 1998 to August-2021 involving the application in wear and corrosion resistance. The studies showed improvement on corrosion and wear resistance with the use of SiC-based nanocomposite coatings. Therefore, the differences in the presented results were due to the size and quantity of SiC nanoparticles used in the nanocomposites, being then, able to be used for material applications involving resistance to wear and corrosion.

Keywords: Ceramics, silicon carbide, nanoparticles, composite.

RESUMO

Os nanocompósitos contendo SiC como nano-reforço têm sido amplamente utilizados em vários campos, como aeroespacial, automotivo e indústrias das áreas militares e marinhas. No projeto e engenharia de materiais, degaste e corrosão são dois problemas em comum para diversas aplicações. Logo, os efeitos de adição de nanopartículas de SiC em compósitos têm sido estudados para melhorar propriedades físico-químicas e mecânicas, como resistência à corrosão e ao desgaste. Neste contexto, este artigo busca apresentar uma revisão da literatura acerca das investigações atuais sobre nanocompósitos contendo nanopartículas de SiC como reforço e com foco aplicação como revestimento envolvendo resistência ao desgaste e corrosão. A pesquisa foi realizada nas bases de dados ScienceDirect e Web of Science, onde foram selecionados trabalhos científicos, utilizando os descritores 'ceramic reinforcement', 'nanocomposite', 'coating', 'SiC', 'silicon carbide', 'wear resistance', 'corrosion resistance' e 'applications'. A partir desta revisão, foram encontrados 17 artigos científicos voltados para a aplicação em resistência ao desgaste e à corrosão no período de 1998 até Agosto-2021. Os estudos encontrados demonstraram aumento na resistência à corrosão e ao desgaste a partir do uso de revestimentos de nanocompósitos à base de SiC. Por conseguinte, as diferenças

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nos resultados apresentados se deram devido ao tamanho e a quantidade de nanopartículas de SiC utilizados nos nanocompósitos, podendo assim, serem utilizados para aplicações de materiais envolvendo a resistência ao desgaste e à corrosão.

Palavras-chave: *Cerâmicas, carbeto de silício, nanopartículas, compósito.*

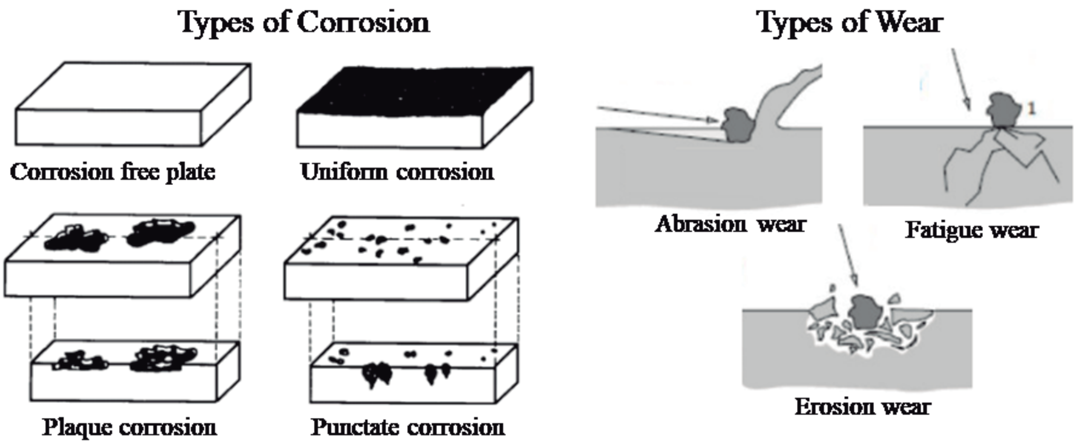
INTRODUCTION

Wear and corrosion are two common problems regarding materials engineered for several applications. Therefore, these two aspects should be considered when designing materials and, particularly, when engineering ceramics and ceramic-based materials (MEDVEDOVSKI, 2001). Wear happens when two material surfaces are in contact and sliding with each other and this can damage one or both parts, leading to a loss of material (HUTCHINGS; SHIPWAY, 2017). On the other hand, corrosion is a type of material deterioration caused by electrochemical and chemical reactions due to the environmental conditions in which the material is exposed (BALAN, 2018).

Thus, carbides have been used as surface coatings for abrasion resistance, mainly in materials such as white steel and cast iron linked to chromium, due to their hardness, size and distribution, increasing wear resistance (MOSLEH-SHIRAZI; AKHLAGHI; YANG, 2016). In this view, silicon carbide (SiC)-based nanocomposites have been investigated to overcome wear and corrosion resistance problems (SHI *et al*., 2006), since, SiC acts as a barrier against corrosion due to its chemical inertness and wear by preventing the movement of discrepancies and leading to accumulation in the material's grain boundaries (JUSOH *et al*., 2018).

It is important to mention that there are many forms of corrosion, shown in Figure 1 (e.g., galvanic corrosion, crevice corrosion, pitting corrosion, etc.) (SHASHIN *et al*., 2019) and they are usually evaluated through electrochemical techniques such as potentiodynamic polarization and/or electrochemical impedance spectroscopy (EIS). The potentiodynamic polarization is widely used, where an electrical potential range is applied to a test electrode (representing the analyte), which results in a polarization curve and several electrochemical parameters (such as corrosion current density and inhibiting efficiency), as well as corrosion rates in a submitted condition, labeled as Tafel slopes (TELEGDI; SHABAN; VASTAG, 2018). On the other hand, EIS evaluates the polarization resistance (an oxidation resistance of the analyte) that can be further used to indirectly determine the corrosion current density, being also a Tafel slope-based characterization method (ATRENS *et al*., 2018). Thus, the potentiodynamic polarization is simpler than EIS and it enables localized corrosion detection.

Figure 1 - Types of corrosion and wear.



Source: Adapted from Shashin et al. (2019).

Regarding the wear of the materials, shown in Figure 1, it can be classified mainly as fatigue, friction, erosion, cavitation, adhesion, and abrasive (BAJWA; RAINFORTH; LEE, 2005). In addition, these materials are obtained through dry sliding wear tests, using pin, disk, and ball devices, which can evaluate a wear rate due to the loss of mass of the material using a constant force (ATRENS *et al*., 2018). The wear resistance of materials is related to the properties of hardness and friction coefficient, that when reduced, leads to a reduced wear resistance (KASIAROVA *et al*., 2004).

Basically, composites are a class of materials composed of two or more materials (with distinct phases called matrix and reinforcement) in order to obtain a better mechanical and physicochemical performance compared to their counterparts (AMIR *et al*., 2019; ZHANG *et al*., 2020). Moreover, when this type of material has one or more dimensions into the nanoscale (1-100 nm) are labeled nanocomposite, where it is characterized by presenting specific properties (VINYAS *el al*., 2019) due to the reinforcement phase be in the form of nanoparticles, nanotubes, nanosheets, nanorods, nanowhiskers, nanospheres and/or nanoplatelets (LICCIARDELLO; PIERGIOVANNI, 2020), such as the increase in mechanical strength and biological properties (SERGUEEVA *et al*., 2009).

In this context, SiC is a non-oxide ceramic material that has as main features good corrosion resistance, chemical inertness, high thermal, and mechanical stability (ABDERRAZAK; HADJ-HMI, 2011; ERAY, 2020), as well as wear resistance when used as a composite coating (BENEA *et al*., 2001). The applications of SiC-based nanocomposites involve a several industries (e.g. automotive, aerospace, chemical, petrochemical, electronics) (SHIN *et al*., 2011; ZENG *et al*., 2018; LIANG *et al*., 2020) and these materials have been used such as nanocomposites to increase the wear and corrosion resistance properties. Thus, the present paper aims to show an overview about the current investigations involving SiC-based nanocomposites with focus on wear and corrosion resistance applications during the period of the 1998 - August 2021, using the scientific platforms Science Direct and Web of Science.

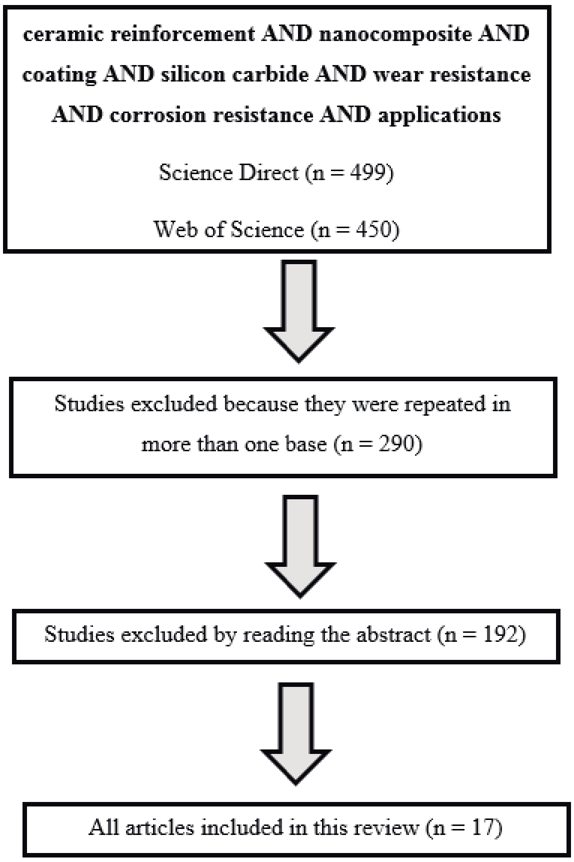
MATERIALS AND METHODS

The research was carried out using the Science Direct and Web of Science databases from 1998 to 2021 in order to draw a global scenery on the subject of work. The descriptors used were: *'ceramic reinforcement', 'nanocomposite', 'coating', 'SiC', 'silicon carbide', 'wear resistance', 'corrosion resistance',* and *'applications'*. For the discussion, it was only considered research papers (scientific articles based on the reading of their abstracts) and the exclusion criteria were: (i) papers that did not present SiC as a composite phase, (ii) papers that did not involve neither wear nor corrosion resistance, and (iii) papers that did not involve any dimension at nanoscale.

RESULTS AND DISCUSSION

Figure 2 shows the flowchart about bibliographic research during 1998-2021 to Science Direct and Web of Science databases, involving SiC-based nanocomposites applied to corrosion and wear resistance applications over time to both scientific databases, where it was found 17 articles in total concerning the research subjects (using the descriptors *'ceramic reinforcement', 'nanocomposite', 'coating', 'SiC', 'silicon carbide', 'wear resistance ', 'corrosion resistance'* and *'applications'*).

Figure 2 - Flowchart of research and analysis of articles.



Source: Author's construction.

CORROSION RESISTANCE

Table I shows the papers, which investigated SiC-based nanocomposite coatings to get corrosion-resistant materials. Thus, it can be seen the predominance of the electrodeposition method to add the nanocomposites under the substrates. In addition, electrochemical tests (predominantly potentiodynamic polarization) were used to correlate the materials behavior under aggressive electrolyte media with their corrosion resistance. In all these cases, the Tafel slope was a crucial data to infer about the corrosion resistance properties.

Table 1 - SiC-based nanocomposites intended for corrosion resistance applications.

Nanocomposite	Substrate	Coating addition method	Application	Particle size (nm)	Corrosion evaluation	Reference
Cu/SiC coating	Pure Cu	DC electrodeposition	Potential fields: boilers, heat and exchangers	40	Potentiodynamic polarization	MIRSAEED-GHAZI *et al*., 2019 (IF: 4.872)
Ni-SiC coating	AZ91 Mg-alloy	DC electrodeposition	Potential fields: automotive	40	Potentiodynamic polarization	FINI; AMADEH, 2013 (IF: 2.917)
Ni-Fe/SiC coating	Permalloy	Electrodeposition	MEMs and mesoscopic systems	50	Potentiodynamic polarization	ATAEE-ESFAHANI *et al*., 2009 (IF: 5.316)
NiP/SiC coating	Low-carbon steel plate	Electrodeposition	Not specified	50-100	Potentiodynamic polarization	AHMADKHANIHA *et al*., 2020 (IF: 2.881)
Ni-P-SiC coating	45 Steel	Scanning electrodeposition	Equipment parts (design)	--------	Potentiodynamic polarization, electrochemical impedance espectroscopy (EIS)	FU *et al*., 2020 (IF: 2.881)
CeO_2-SiC coating	Al5083 alloy	Friction stirs processing (FSP)	Potential fields: automotive and marine	50-80	Potentiodynamic polarization	AMRA *et al*., 2015 (IF: 1.819)
Al_7O_{75}-2%SiC	None	Stir casting followed by FSP	Potential fields: structural and automotive	40-80	Potentiodynamic polarization	KUMAR *et al*., 2017 (IF: 5.01
r-Go/SiC c oating	Pure Mg	Addition of precursors *in situ*	Structural materials for brackish environments	30-80	Potentiodynamic polarization	RAMMASAMY *et al*., 2016 (IF: 6.707)
Cu-P/SiC coating	Carbon steel	Electroless plating	Potential fields: materials, mineral and chemical	40	Potentiodynamic polarization	FARAJI *et al*., 2015 (IF: 2.433)

Source: Author's construction.

According to the Table 1, SiC-based nanocomposite coatings intended for enhancing the corrosion resistance of metallic substrates are mostly added by electrodeposition methods. For example, SiC/Cu nanocomposites were added to pure Cu substrate, and due to SiC nanoparticles, the corrosion resistance was 1.4-2.5 times greater than the pure substrate and it increased with increased matrix/reinforcement volume fraction. This corrosion properties improvement characterized by lesser corrosion current densities and inhibiting efficiency ranging from 30-60% lied on the ability of the nanocomposite coating to fill surface defects, active corrosion sites, and possible corrosion pits as well as lead to decreased occurrence of anodic and cathodic reactions (MIRSAEED-GHAZI *et al*., 2019).

In the case of Mg-based alloys, which are highly susceptible to corrosion in aggressive media, SiC nanoparticles were added to a nickel (Ni) matrix due to both corrosion and wear resistance. In the same study, it was observed that the corrosion current density significantly decreased (~17 times less) with the increase of SiC content in the reinforcement phase, and this also happened with the corrosion potential (maximum increase of a 5-fold magnitude). A reasonable explanation for such results is the protective effect of Ni matrix allied with the SiC anti-corrosive reinforcement that results in qualitatively decreasing the corrosion active areas, changing the path available for corrosion, and reducing the superficial defects enhancing corrosion resistance (FINI; AMADEH, 2013).

SiC-based nanocomposite coatings can also be applied to magnetic alloys. In this sense, SiC nanoparticles (mass fraction of 2.5%)-reinforced Ni-Fe coatings were applied to permalloy and the corrosion resistance was evaluated in terms of corrosion potential (1,2 times lesser for the nanocomposite) and (17 times lesser than the control coating). The authors showed that the SiC nanoparticles incorporation gave an inert/protective layer to the alloy and trend to decrease the defects on its surface, enhancing corrosion resistance (ATAEE-ESFAHANI *et al*., 2009).

Regarding combinations of NiP/SiC to form nanocomposite coatings, some care should be taken with thermal treating, as seen on the study of Ahmadkhaniha *et al.* (2020). Despite the focus of the study was to investigate the structural modifications on the β-SiC nanoparticles-based nanocomposite coatings, the nanocomposite coating did not affect the corrosion resistance behavior of the resulting material (corrosion potential increased from 0.40 V to 0.19 V, and the current density decreased from 1.8×10^{-6} to 1.2×10^{-6} A/cm^2), due to the problem of microstructural changes in NiP matrix under heat treating which leads to micro-cracks formation in NiP coatings.

Without applying heat-treating, SiC nanoparticle reinforcement-based NiP nanocomposite seems to present corrosion resistance improvement, as shown in Fu *et al.* (2020). The authors investigated the effect of this nanocomposite on polished and sand-blasted samples. In brief, the study confirmed the better corrosion properties of the nanocomposite coating by the significant decrease in corrosion current density (it decreased about 46% for polished samples and 36% for sand-blasted) and the increase on corrosion potential in potentiodynamic polarization (that increasing was 64% for polished samples and 86% for sand-blasted samples), which is corroborated by the visual increase of impedance arc radius obtained by EIS. Moreover, it was possible shown that the uniform incorporation of SiC nanoparticles, mainly with a sandblasting pre-treatment served as an inert barrier against corrosion.

In addition to parameters as corrosion potential, the pitting potential can be estimated by potentiodynamic polarization, as made by Amra *et al*. (2015), which investigated CeO_2 (50 nm) and SiC (80 nm) nanoparticles-based nanocomposite to coat an Al5083 aluminum alloy. In this case, there were results were using cerium oxide as the matrix and SiC as the reinforcement, which showed an increase of the 40% for corrosion potential and a 10% for pitting potential. The authors concluded that the cerium oxide acts as a cathodic inhibitor that turns pitting corrosion difficult to aluminum alloys, while the inertness of SiC enhances the protective role of surface against substrate corrosion.

Concerning aluminum casted alloys, SiC can be used to produce a nanocomposite with improved corrosion resistance, such as casted Al7075-2% SiC. By evaluating the nanocomposite electrochemical performance, both corrosion and pitting potential values were lesser than those of Al7075 bare material, the corrosion current decreased about 80%. Furthermore, all the results were ascribed to the FSP method, which not only provided corrosion active area decreasing due SiC inertness, but microstructure changes such as better homogeneous dispersion of SiC on the nanocomposite, interfacial bonding, and grain size refinement (compared to a SiC microcomposite, the nanocomposite presented an average grain size about 58% lesser) (KUMAR *et al*., 2017).

It is also possible to combine different nanostructures to get corrosion-resistant materials. Such combination involving reduced-graphene oxide (r-GO) and SiC nanoparticles-based nanocomposite coated on pure magnesium was investigated in Rammasamy *et al*. (2016) and the inhibiting efficiency was 85% for the proposed nanocomposite coating compared to rGO (73%) and SiC (27%) coatings only. Additionally, that investigation used the i*n* situ mixing of precursors to add the coating into the substrate and it concluded that the enhanced corrosion resistance for the r-GO/SiC nanocomposite was due to SiC ability to reduce localized corrosion.

It is also worthy to mention that SiC-based nanocomposite coatings can be produced by electroless methods as in Faraji *et al.* (2015), which studied the effect on the corrosion resistance after coating a carbon steel with a nanocomposite formed onto a Cu-P matrix and SiC nanoparticles as the reinforcement. Succinctly, the corrosion current density showed a reduction of the 73% for the nanocomposite coating compared to the bare carbon steel, meanwhile the inhibition efficiency was 74%, indicating significant corrosion resistance improving. Moreover, the great results were due to SiC nanoparticles that act as a physical/protective layer for the substrate (confirmed by optical microscopies) and whose SiC particles uniform distribution (averaged size of 80 nm and 99% purity) plays a role in providing thermodynamic stability to the resulting material.

As expected, in almost all studies from literature with exception of the use of the nanocomposite coatings improved corrosion resistance based on potentiodynamic polarization characterization results.

WEAR RESISTANCE

Table 2 presents SiC-reinforced nanocomposite coatings to obtain materials with high wear resistance. The predominance of the electrodeposition method for the synthesis/deposition of nanocomposites stands out. In addition, wear tests (predominantly using Al_2O_3 pins and balls) were used to relate the mechanical properties under constant force, highlighting the properties of hardness and friction coefficient, which are directly responsible for the wear rate.

Table 2 - SiC-based nanocomposites intended for wear resistance applications.

Nanocomposite	Substrate	Coating addition method	Application	Particle size (nm)	Wear resistance (μ= coefficient of friction, β= wear rate and γ= hardness)	Reference
Al/SiC coating	Pure Al	Friction Processing	Potential fields: automotive and aviation	50	Al/SiC with steel H-13 and a pin length of 6 mm (μ= 0,65-0,75, β= 0,002-0,005 (10-30N) and γ= 140 HV) Al/SiC with steel H-13 and a pin length of 3.2 mm (μ= 0,8-0,9, β= 0,0025-0,0075 (10-30N) and γ= 155 HV)	SAADATMAND *et al*., 2014 (IF: 1.819)
Mg/SiC coating	Pure Mg	Processing quasi-static hot pressing	Potential fields: automotive and aerospace	75	Substrate Mg (β= 0,04 (20N) and γ= 48 HV) Mg with 10% SiC (β= 0,028 (20N) and γ= 70 HV)	MAJZOOBI *et al*., 2018 (IF: 2.626)
Cu-Ni-W/SiC coating	Cu-Ni-W	Electrodeposition	Potential fields: automotive and aerospace	15	Cu-Ni-W (β= 0,015-0,020 (20N) and γ= 450 HV) Cu-Ni-W 10%SiC (β= 0,005-0,006 (20N) and γ= 520 HV)	DEHGAHI *et al*., 2016 (IF: 3.784)
Cu-Ni-W/SiC coating	Cu-Ni-W	Electrodeposition	Not specified	50	Cu-Ni-W 0,5% SiC (μ= 0,38 and γ= 260 HV) Cu-Ni-W 5% SiC (μ= 0,16 and γ= 340 HV)	HASHEMI *et al*., 2014 (IF: 6.901)
Ni/SiC coating	Pure Ni	Electrodeposition	Potential fields: oil and gas	45-200	Ni nano-45SiC (β= 0,0004-0,0009 (0,1-10Hz) and γ= 285 HV) Ni micro-200SiC (β= 0,001-0,0013 (0,1-10Hz) and γ= 255 HV)	LANZUTTI *et al*., 2019 (IF: 4.872)
Ni/SiC coating	Pure Ni	Magnetic pulse electrodeposition	Potential field: mechanics	30-200	Ni nano-30 nm SiC (β= 0,037 (10N) and γ= 903 HV) Ni micro-200 nm SiC (β= 0,076 (10N) and γ= 598 HV)	PEN *et al*., 2019 (IF: 4.527)
Ni-Co/SiC coating	Ni-Co	Electrodeposition	Not specified	50	Ni-Co (γ= 120 HV) Ni-Co 11%SiC (γ= 200 HV)	BAHADORMANESH *et al*., 2011 (IF: 5.316)
Ni-Zn-P/SiC coating	Ni-Zn-P	Electrodeposition	Not specified	50	Ni-Zn-P (μ= 0,53, β= 0,06 (10N) and γ= 300 HV) Ni-Zn-P 10%SiC (μ= 0,70, β= 0,025 (10N) and γ= 460 HV)	POULADI *et al*., 2012 (IF: 4.158)

Source: Author's construction.

The wear rate of Al/SiC with steel H-13 and a pin length of 6 mm was lower than that of Al/SiC with steel H-13 and a pin length of 3.2 mm, about 0.002 to 0.0025 respectively; this is attributed to the values of friction coefficient, hardness, and nanoparticle dispersion in the aluminum matrix. The Al/SiC with steel H-13 and a pin length of 6 mm presented a friction coefficient from 0.8 to 0.65 compared to the Al/SiC with steel H-13 and a pin length of 3.2 mm, this friction characteristic is responsible for the shear stresses on the surface of the material (abrasion rate per particulate). It denotes the decrease in abrasion with the increase of SiC nanoparticles and the increase in the abrasion rate with the increase in the resistance of the abrasion tests, due to the silicon carbide preventing the movement of disagreements (SAADATMAND *et al*., 2014).

The high wear resistance of magnesium matrix nanocomposites with SiC nanoparticle reinforcement is given by the increase in hardness from 48 to 70 HV, as well as the strong bond between the nano-reinforcement and the Mg matrix, facilitating the transfer of charges to the hard particles. Furthermore, with the increase of SiC nanoparticles, it results in a decrease in the wear rate from 0.04 to 0.028, because the nanoparticles agglomerate increasing the mechanical strength (MAJZOOBI *et al*., 2018).

Regarding the Cu-Ni-W matrix nanocomposites containing 10% w/w SiC nanoparticles as reinforcement, a significant decrease in the wear rate was obtained from 0.015 to 0.005, this decrease was due to increase of the SiC on the microhardness and promoting the development of superficial porosities, due to the effect of 3 mechanisms: (a) Orowan mechanism (scattering strengthening - matrix and reinforcement prevent displacement movement, resulting in displacement accumulations in grain boundaries), (b) matrix mechanisms and microstructure of the particle (matrix deformation is constrained by particle incorporation causing charge to be carried so much by the matrix or hard particle) and (c) Hall-Petch mechanism (associated grain refinement reinforcement to structural refinement due to nucleation of smaller surface grains) (DEHGAHI *et al*., 2016).

The tribological properties of a Cu-Ni-W/SiC nanocomposite were determined by the values of friction coefficient and hardness, being respectively 0.5% w/w SiC (μ= 0.38 and γ= 260 HV) and 5% w/w SiC (μ= 0.16 and γ= 340 HV). The increase in hardness was a result of grain refinement, an increase in grain boundaries which prevents the movement of disagreements and intrinsic limits. In addition, the decrease in the coefficient of friction and decrease in wear resistance was attributed to excess plastic deformation of the nanocomposite surface generated by the agglomeration of SiC nanoparticles, which are responsible for forming voids on the material surface (HASHEMI *et al*., 2014).

The nanocomposites containing Ni and nano SiC reinforcement showed lower wear rate values from 0.001 to 0.0004 compared to micro SiC, due to the material's hardness properties (255 to 285 HV); in the case of the microcomposite, the wear rate is related to the hardening effect combined with the refinement of the grain and the strengthening of the dispersion of the matrix with the reinforcement. The nanocomposite is directly related to the Hall-Patch equation that relates the particle size and grain contour of the material. In addition, the wear behavior of the Ni/SiC nanocomposite at high frequency (10Hz) showed values similar to that of the microcomposite (LANZUTTI *et al*., 2019).

The mechanical properties of hardness and wear resistance are presented in the values of micro-reinforcement nanocomposites (β= 0.076 (10N) and γ= 598 HV) and nano-reinforcement (β= 0.037 (10N) and γ= 903 HV), these results are attributed to 3 factors; (a) particle size; (b) dispersion in the matrix; and (c) particle structure. Decreasing the particle size results in an increase in both hardness and wear resistance. In addition, the synthesis by magnetic pulse electrodeposition promotes fine, compact, and uniform structures, resulting in increased mechanical properties (PEN *et al*., 2019).

As shown in Table 2, Ni-Co matrix nanocomposite had a hardness of 120 HV. When the SiC nanoparticle reinforcement was added, there was an increase of about the 80%, the wear rate was 15% lower than without nano-reinforcement, and this is attributed to a set of factors such as: (a) quantity of particles, (b) size of dispersed phases, (c) spacing between particles, (d) particle distribution and particle morphology and (e) structure and mechanical characteristics of the matrix, resulting in an increase in the boundary quantities of grains, increasing wear resistance (BAHADORMANESH *et al*., 2011).

The addition of SiC nanoparticles in the Ni-Zn-P composite promoted an increase in hardness from 300 to 460 HV, coefficient of friction (0.53 to 0.70) and a decrease in wear rate from 0.06 to 0.025. The result of the wear rate was related to the impediment of the displacement movement of the SiC nanoparticles, resulting in an increase in the unevenness in grain boundaries (POULADI *et al*., 2012).

As expected, in all studies in this literature review, the use of nanocomposite coatings improved hardness as well as wear resistance based on the results and, in addition to that, it also determined whether there was a relationship of particle size with hardness and resistance to wear properties.

CONCLUSION

The emerging publications involving nanocomposites and corrosion/wear properties denotes the relevance of this subjects in nanoscience and engineering. Based on the works found in the literature, it is possible to highlight the use of electrodeposition as a main method to obtain nanocomposite coatings using SiC nanoparticles. Furthermore, it was confirmed that the use of SiC nanoparticles as a nano-reinforcement significantly increases wear and corrosion resistance, currently mainly as a coating of different surfaces. Then, SiC-based nanocomposites could be used as potential materials in the fields of automotive, aerospace, and military industries to overcome wear and corrosion problems. Moreover, SiC nanoparticles size and distribution form in the nanocomposite directly influence the wear and corrosion resistance properties, being considered important factors when designing corrosion and wear resistant nanomaterials.

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