25th ABCM International Congress of Mechanical Engineering
October 20-25, 2019, Uberlândia, MG, Brazil

COB-2019-2170
MICROSTRUCTURAL AND MECHANICAL ANALYSIS OF POLYTETRAFLUOROETHYLENE COMPOSITES WITH QUASICRYSTALS REINFORCEMENT

Aline Karla Barbosa da Silva

Antonia Pamela de Sousa

Angel Roberta Oliveira Sousa

Danielle Guedes de Lima Cavalcante
Universidade Federal da Paraíba - Campus I - Lot. Cidade Universitaria, PB, 58051-900
alinekarla.akbs@gmail.com, pamelasousa-@hotmail.com, angel.r.o.sousa@gmail.com, danielleguedes02@gmail.com

Antônio Paulino de Araujo Neto
Universidade Federal do Rio Grande do Norte – Campus I – Lagoa Nova, RN, 59064-741
tonypaulino14@hotmail.com

Juliana Ricardo de Souza
Instituto Federal do Rio Grande do Norte – Campus Mossoró, RN, 59628-330.
julianars.materiais@gmail.com

Abstract. *The development of new materials that may contribute to the improvement of tribological systems such as reduced friction and decreased wear has been of interest to researchers worldwide. The use of PTFE as a high performance thermoplastic has already been established in the market due to its excellent surface characteristics, low coefficient of friction, and high lubrificity, associated to the high performance under impact. Among the disadvantages in the use of this material is the low wear resistance as well as limited mechanical resistance. The objective of this work was the development of PTFE composite with powder loading of quasicrystalline alloys in order to obtain a material with excellent surface characteristics, due to the characteristics of the matrix as well as the metallic powder, associated with high wear resistance and mechanical properties. quasicrystalline reinforcement. The composites showed good density after sintering Besides low porosity, so the viability in the development of composite PTFE/QC, with better mechanical performance characteristics//surface when compared to precursors and pure PTFE elements.*

Keywords: *quasicrystalline, PTFE, resistance.*

1. INTRODUCTION

With technological advances and the need for materials for increasingly specific uses, composite materials are part of a growing research field, especially in the advanced industry, such as the automotive and aerospace industries (Moreira, 2008). The polymeric matrix composites and metallic fillers are among the most studied composites, allowing the combination of the characteristics of mechanical strength, hardness, higher thermal stability, wear resitante, among other characteristics, of low density metallic materials and ease processing of polymeric materials (Silva, 2018; Biscainho, 2017).

Currently there are growing studies of the class of quasicrystalline alloys (QC), which were a huge discovery for the replacement of conventional metallic fillers in composites because despite their fragility, their excellent surface properties such as hardness, wear resistance, among others, provides its use for the development of composites, as a way to enjoy their best properties (Cavalcante, 2011).

The use of polytetrafluoroethylene (PTFE) as a high performance polymeric material, because of its high degradation temperature, around 600ºC, also has excellent characteristics of high lubricity, low friction coefficient, good thermal stability, among others, justifying its study and developmment increasing in the market, thus allowing it to be used in several applications, such as pan coating (Silva, 2018; Paoli, 2008; Hemais, 2003).

The objective of this work is the analysis of powders, fabrication, characterization and evaluation of some properties of quasicrystalline fillers reinforced PTFE matrix composite.

2. METODOLOGY

The quasicrystalline filler (AlCuFe) was produced by gas atomization and was supplied by the company SAINT-GOBAIN-Fr with a grain size in the range of 170-190 μm, subjected to a heat treatment. And polytetrafluoroethylene (PTFE) was assigned by the Tribology and Structural Integrity Study Group – GET UFRN, manufactured by FLUORSELLE. These powders were characterized by X-ray Diffraction (XRD) characterization to identify present phases and crystallinity.

Volumetric fraction formulation of te quasicrystalline filler content was performed according to Tab. 1. The powders were weighed and mixed in a mini processor for 60 seconds for each formulation and then the material was taken to mold, compacted and hot pressed with a heating rate of 10ºC/min until it reaches the temperature of 220ºC and then applied a load of 3 tons for 3 minutes, so composites with 0%, 1%, 5%, 10%, 15% and 20% formulations were made in volumetric fraction of quasicrystalline fillers. The composites then underwent a visual inspection and characterization of Scanning Electron Microscopy (SEM) and ultra-hardness.

Table 1. Volumetric fraction formulation of PTFE/QC composite.

Composite formulation	PTFE (%Vol.)	QC (%Vl.)
1	100%	
2	99%	1%
3	95%	5%
4	90%	10%
4	85%	15%
6	80%	20%

2.1 Thermal treatment of quasicristalline powder

The quasicrystalline powder was subjected to homogenization heat treatment in order to reduce the heterogeneity of remaining crystalline phases of the atomization process, making the alloy 100% quasicrystalline. The powder was held in vacuum for a period of 1h, then heated (750°C) with a heating rate of 30°C/min for a time of 3h (NABERTHEM).

2.2 X-ray powder diffraction (XRD)

It was used the Phaser Bruker D2 Diffractometer, operating with 30 kV and 10 mA Copper Kα radiation, with 2θ scanning between 20 and 100 degrees with 0.02° pitch and 1mm slit for analysis of effective quasicrystalline phase formation and to assess the degree of crystallinity and whether PTFE powder impurities were present.

2.3 Composite Electronic Scan Microscopy (SEM)

SEM characterization was performed to evaluate the material microstructure, morphology and particle distribution. The samples were previously prepared, fixed on a carbon tape and metallized. The analysis proceeded on a Scanning Electron Microscopy, using the FEI environmental Quanta 450 model equipment.

2.4 Ultra-microhardness

The ultra-microhardness test enables microhardness gain analysis of composite samples as the load content is increased, as well as through the standar deviation found by the elastic modulus (GPa) results by quasicrystalline load content in the polymeric material, allows to verify the distribution of quasicrystalline particles in the PTFE matrix, corroborating with the SEM images. It was performed using a 50 mN ultramicrodurometer using a Berkovich indentator (triangular pyramid). 7 indentations were performed in each sample for 10 seconds in each indentation.

3. RESULTS

3.1. XRD

Through XRD, observed in Fig. 1, it is possible to visualize the presence of two phases, the icos-ceric phase AlCuFeB, isostructural phase of the i-AlCuFe phase, and the cubic phase (solid solution) β Al50-x (Cu, Fe)50+x, mostrly icosaedral phase. This β phase is justified as it coexists with the icosaedral quasicrystalline phase, when the obtaining process does not provide the necessary thermodynamic conditions for the alloy to become completely quasicrystalline. Already in Fig. 2 it is possible to observe that the β phase practically disappears due to the accomplishment of the heat treatment in the quasicrystalline powder, corroborating with the literature (Cavalcante, 2011; Barros, 2015).

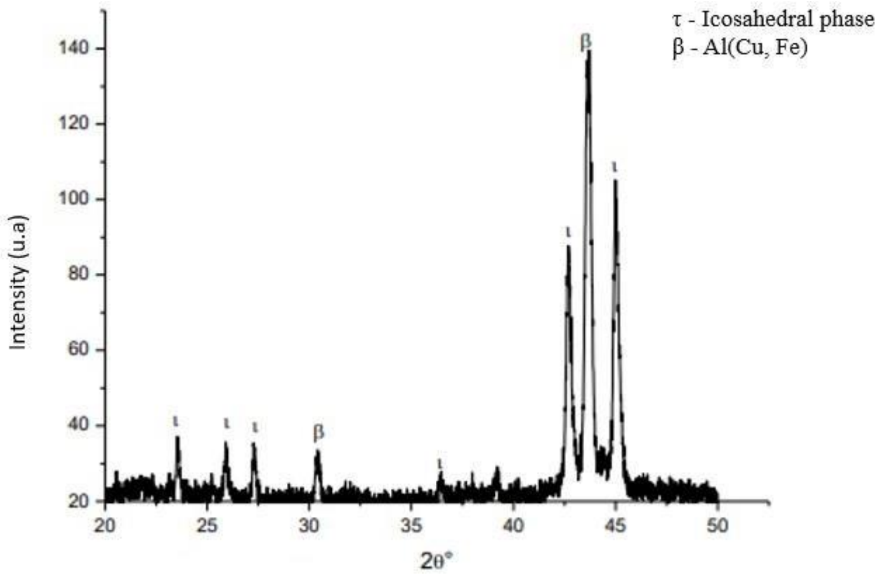

Figure 1. Diffractogram – Atomized composition of the nomnial composition $Al_{59}Cu_{25,5}Fe_{12,5}B_3$ containing the icosahedral phases and the β-Al(Cu,Fe) phase.

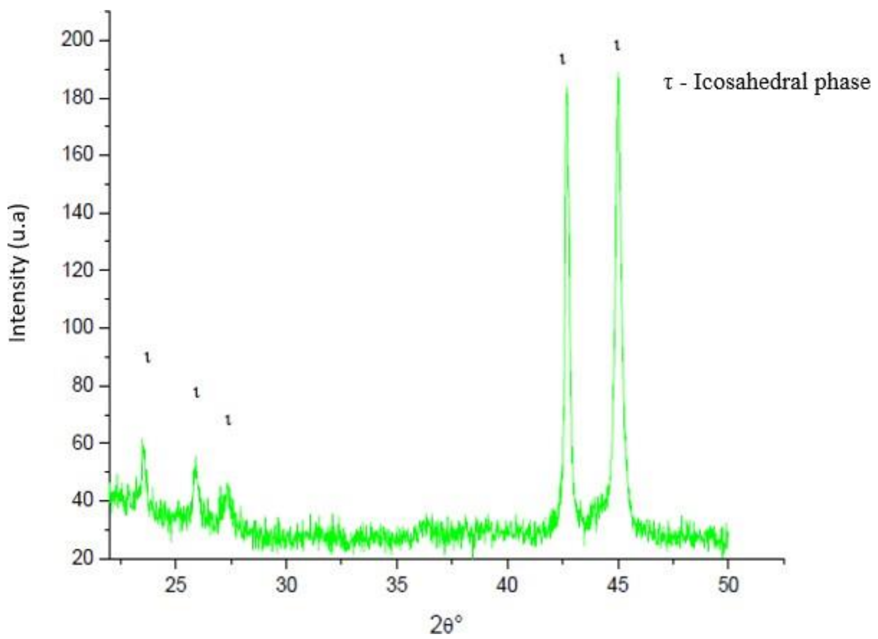

Figure 2. Post thermal treatment diffractogram.

As can be seen in Fig. 3, the XRD of PTFE polymeric material and the presence of semicrystalline structure with smaller amorphous region, showing narrower peaks, indicating a more regular crystalline structure, corroborating the work of Souza (2015).

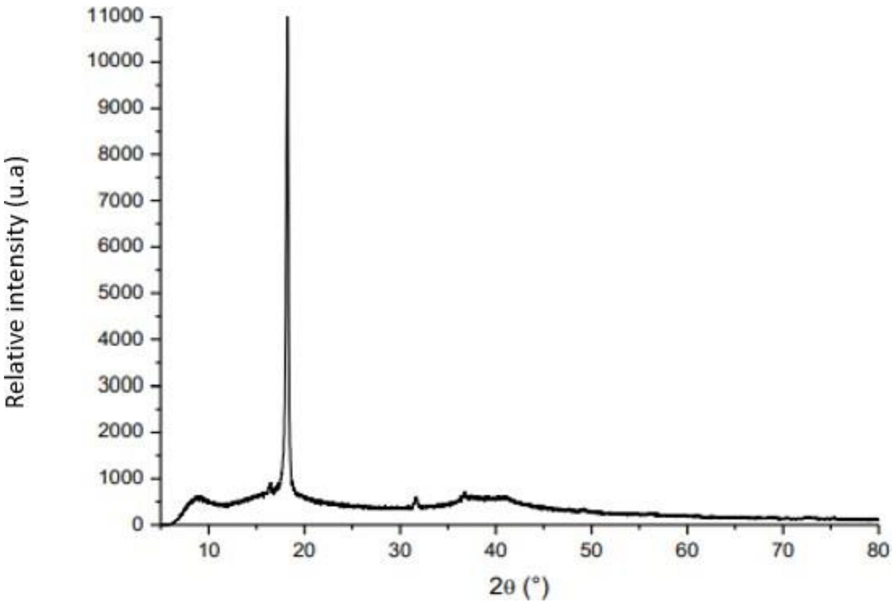

Figure 3. PTFE XRD.

3.2. Composite analysis

After the fabrication of the composite, it was possible to observe in Fig. 4, a grayish coloration as the quasicrystalline content increased, corroborating with the literature (Martins, 2016).

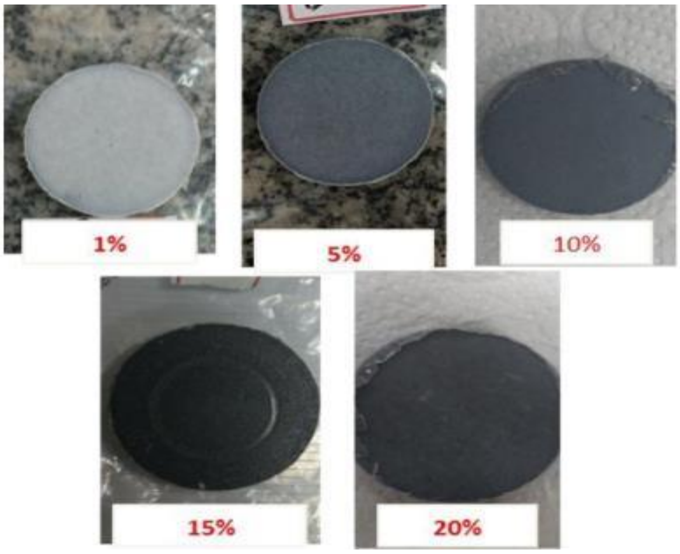

Figure 4. Composite samples of PTFE/quasicrystal with increase of quasicrystalline content.

The Scanning Electron Microscopy showed a good distribution of the particles. The lighter region are the quasicrystalline particles, and also small cracks, striations and some clusters were observed, possibly due to the particle size (Barros et al., 2018), seen in Fig. 5.

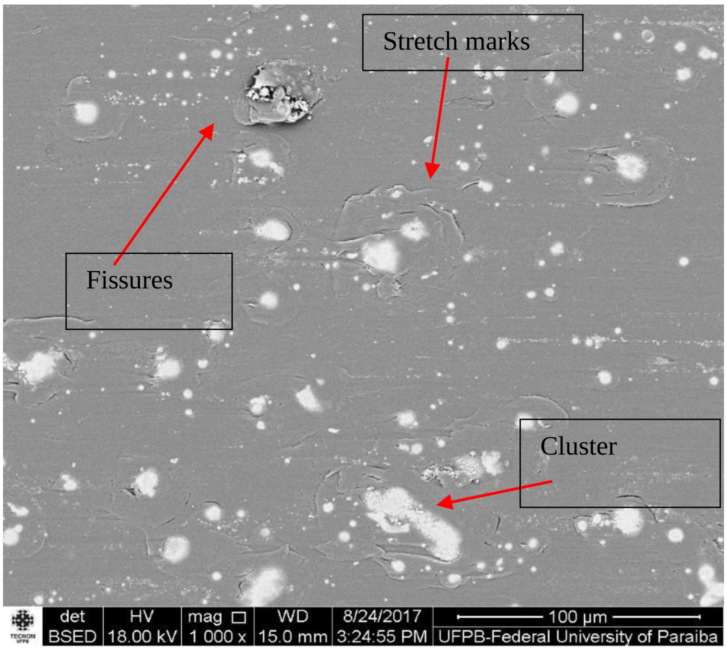

Figure 5. PTFE/QC 10% composite sample.

3.3. Ultra-microhardness

In Figure 6 it is possible to observe the elastic modulus as a function of the quasicrystalline load increade, loads up to 5% are added and no great variation in the modulus are observed.

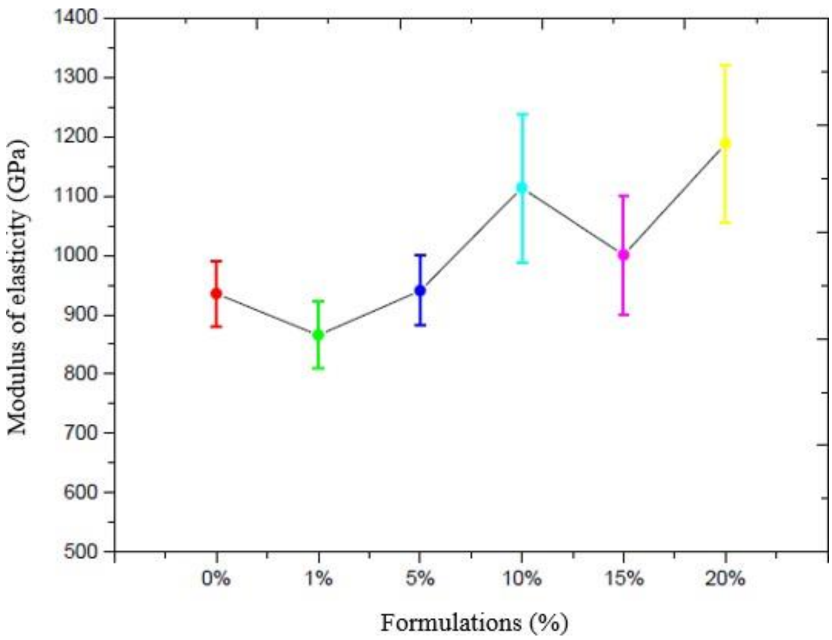

Figure 6. Elastic modulus in function of the quasicrystalline content.

According to Silva(2018) quasicrystalline filler added to polymer have as one of the incorporation effects to function as fillers do polymers, modifying mechanical properties. According to the author`s studies, by using this fillers, the elastic modulus of the polymers can be increased, allowing them to withstand higher loads.

4. CONCLUSION

It was possible to obtain PTFE composites with the addition of up to 20¨% in quasicrystals volumetric fraction through hot compression sintering, observing a good anchoring of the quasicrystals particles to the matrix, thus allowing an increase of the elastic modulus of the composite in relation to pure PTFE..

5. ACKNOWLEDGEMENTS

Thanks to CAPES for the financial support that allowed this research.

6. REFERENCES

Barros, T.P.S., 2015. *Estudo de Dureza e Propriedades Superficiais do Compósito epóxi/ quasicristal.* Ph.D. thesis, Universidade Federal da Paraíba, João Pessoa, Brasil.

Barros, T.P.S., Cavalcante, D.G.L., Oliveira, D.F., Caluête, R.E., Lima, S.J.G., 2018. *"Study of the surface properties of theepoxy/quasicrystal composite". Journal of Materials Research and Technology*, Vol. 8, No. 1, pp. 590-598.

Biscainho, C.A., 2017. "BEQ- Materiais Compósitos: um dos maiores avanços". 09 jun. 2019 <https://betaeq.com.br/index.php/2017/05/19/materiais-compositos/>.

Cavalcante, D.G.L., 2011. *Desenvolvimento de Compósitos Auto-lubriicantes de ligas quasicristalinas/Bi, Sn*. Ph.D. thesis, Universidade Federal da Paraíba, João Pessoa, Brasil.

Paoli, M.A., 2008. Degradação e Estabilização de Polímeros. 2ª versão on-line (revisada), pp. 135-141.

Hemais, C.A., 2003. "*Polímeros e a Indústria Automobilística". Polímeros: Ciência e Tecnologia*, Vol. 13, No. 2, pp. 107-114.

Martins, M.A., Passos, T.A., Cavalcante, D.G.L., Lima, S.J.G., Gomes, R.M., 2016. *"Caracterização Microestrutural De Ligas Quasicristalinas Alcufe (Mn = 0.5, 1, 3, 5)".* In *22º CBECiMat - Congresso Brasileiro de Engenharia e Ciência dos Materiais 2016*. Rio Grande do Norte, Brasil.

Moreira, A.M., 2008. *Materiais de construção I. Materiais Compósitos*. Instituto Politécnico de Tomar e Escola Superior de Tomar. Tomar do Geru, pp.1-5.

Silva, A.K.B.,2018. *Estudo das Propriedades Tibomecânicas de Compósitos de Politetrafluoretileno com Quasicrital*. Dissertation, Universidade Federal da Paraíba, João Pessoa, Brasil.

Souza, J.R., 2015. *Desenvolvimento de compósitos tribologicamente eficazes*. Ph.D. thesis, Universidade Federal do Rio Grande do Norte, Natal, Brasil.

7. RESPONSIBILITY NOTICE

The authors are the only responsible for the printed material included in this paper.