JOURNAL OF MODERN MANUFACTURING SYSTEMS AND TECHNOLOGY (JMMST)
e-ISSN: 2636-9575
VOL. 4, ISSUE 2, 23 – 29
DOI: https://doi.org/10.15282/jmmst.v4i2.4214

ORIGINAL ARTICLE

Synthesis, Preparation and Characterization of H_3BO_3 Nanoparticles as an Additive for Machining Lubricant

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ABSTRACT – The minimum quantity lubrication (MQL) plays a critical role in providing excellent machining performance and application of nanoparticles in base fluids are one of the best way for MQL in machining. The boric acid nanoparticles which are eco friendly are one among the exceptional to demonstrate the outstanding properties. This paper gives report on the enhancement of heat transfer performance in various machining applications, the nature of dilute colloidal suspensions in the medium of base fluids are necessary. The H3BO3 nanoparticles synthesis, preparation and, characterization are crucial for their stability in the suspensions to exhibit excellent Nanofluid properties. In this investigation, the preparation of boric acid nanoparticles using mechanical ball milling and XRD for synthesis and characterization.These nanoparticles in base fluids gives outstanding performance in all machining operations and acts as a good industrial lubricant.

ARTICLE HISTORY
Revised: 25th August 2020
Accepted: 30th September 2020

KEYWORDS
Boric acid
Mechanical Ball Milling
XRD
Lubricants
Nanoparticles

INTRODUCTION

Drilling is well known machining process in the form of hole making in manufacturing industries that involved in the formation of major cutting forces and temperatures and the lubrication enhanced more critical for minimization of it. The conservative cutting fluids are engaged in the machining had definite boundaries with look upon environmental moreover financial reason. The progress of coolants that be environmental is attaining decisive. Within the circumstance, the function of solid lubricants had proved as a practical option for usual cutting fluid and also drop in ecological contamination is main alarm in the current scenario of modern industries. Growing contamination-preventing schemes internationally and user hub on environmentally aware commodities had set better load on industries to reduce the lubricant usuage. It is noticed that lubricants can cause severe inconvenience, the key issues being those associated to surroundings protection, workforce strength, etc. Nevertheless, the lubricant use cannot be influenced not here in sight of elevated forces and temperatures occurred during machining. The heat developed in machining badly and crucially affected the products quality.

As a alternative to conservative fluids, the researchers worked on experimentation with environmental along with cryogenic fluids, in sequence to ease the heat developed in machining zone by dropping out friction coefficient and wear. The efficiency of cryogenic fluids seem to augmented at elevated feeds. It abridged the enormity of tensile residual stresses for all materials, although to altering degrees, beneath all levels of feed. This is endorsed to able cooling act, enhanced modes of chip development, a lesser amount of specific energy and at last, lower grinding region temperature and also challenge of current machining industries is principally persistent on attainment of high eminence, in requisites of work part dimensional precision, surface roughness, high production rate, less tool wear on cutting tools, and increases the product recital with abridged environmental impact. In most realistic appliances of engineering workings, materials experience from worsening by mechanical and chemical possessions nearby effective environments [1].For this we use nanofluids as lubricant in machining. Nanofluid is a recent category of fluids engineered by dispersing nanometre-size solid particles in foundation fluids to intensify heat transfer and tribological properties. MQL is to provide a infinitesimal measure of cooling lubricant standard to the tool-workpieces crossing point, that can enormously ease the practical quantity of cutting fluid. This is to widen a construction viable and surroundingsally benevolent grinding method. Formerly a revise had conceded out in the region of ecological sustainable industrialized by means of hygienic machining utilizing least measure of lubricant as MoS2 powder and grease based graphite assorted with water and SAE 20 oil in different sizes instead of flooding coolant. Advances in contemporary tribology had recognized several solid lubricants that are capable in favour of nourishing and providing lubricants in excess of broad array of temperatures. For the most part of these lubricants, that comprise of graphite, molybdenum disulphide, tungsten disulphide and calcium fluoride, boric acid fit towards exceptional set of materials recognized as lamellar solids.

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MINIMUM QUANTITY LUBRICATION (MQL)

MQL demotes towards the employ of a accuracy point to provide a miniscule quantity of coolants to the tool-workpieces crossing point – characteristically at a stream of 50 to 500 ml/hour –that is concerning 3 to 4 preparation of scale lower quantity usually used in a flood cooling condition. MQL had been extensively wilful in numerous machining processes. MQL grinding is immobile a quite new-fangled research area, and some of the researchers had deliberated MQL grinding. The literature reported that a appropriate assortment of the MQL system with cutting parameters, it is promising for MQL machining to get hold of performances alike to flood lubricated environment, in provisions of lubricants, tool life and, surface finish. The MQL had numerous advantages compared with conventional wet and dry machining. In present scenario, many of researchers had recommended that MQL shows possible competitiveness in provisions of tool life, surface finish and cutting forces in machining. An assortment of ways had been reported to blend Nano level materials [17] and can be simply scaled up to outsized quantities [18]. In mechanical behaviour, powder particles are subjected to a brutal plastic deformation [19, 20 and, 21].

BORIC ACID AS LUBRICANT IN MACHINING

The conservative cutting fluid is a green pollutant and the government had severe rules warning the clearance of acerbic fluid water. Long term expertise to cutting fluid can root dermatitis, a nonspecific medical term that describes skin disorders ranging from a hideous reaction to wicked cancer [2]. The lubricant gratis machining process is adequate only when it is potential to assurance that the part eminence and machining times will improve on or be equal to those achieved in flood coolant machining [3]. MQL machining, which uses 10% boric acid mixed with SAE 40 base oil, is a surroundings safe option to conservative metal cutting. Quite a few reports correlated to the coolant properties of boric acid had passed out more than the precedent decades [4, 5]. Of late, research exclusively meant for use of boric acid in engineering systems had been considered [6, 7, 8 and, 9]. Other vital investigation had use of boric acid as a coolant in machining operations. In metal forming applications [10, 11 and, 12], it had revealed that boric acid provided very low friction (0.04) between an aluminium work piece and a steel forming tool. In the former work by Liang and Jahanmir [13]. H_3BO_3 is, for the most part well-liked solid lubricants and had excellent lubrication properties devoid of calling for steep throwing away techniques. As described in the foreword, boric acid is one more regularly unobserved lamellar solid that had been originated to be an successful lubricant [6, 7, 8 and, 9]. As reported in the narrative, the shear strength of boric acid had been trial determination to be 23MPa, and its friction coefficient had been deliberated to be less than 0.02 in ambient surroundings [14]. The basic molecular configuration of boric acid allows it to do something as an efficient solid lubricant film [15] when crystallized. When appropriately associated with a substrate, boric acid will exhibit minimal friction and supply valuable parting flanked by surfaces [14]. Machining performance of SAE 40 oil containing dissimilar weight scope of graphite and boric acid is investigated in turning [16].

SYNTHESIS AND CHARACTERIZATION OF NANOPARTICLES OF BORIC ACID

Boric acid (H_3BO_3) also known as boracic acid or orthoboric acid, is naturally taking place compound containing elements boron, oxygen, and hydrogen (H_3BO_3). The physical, chemical and, other allied properties are shown as follows:

- Molecular Blueprint: H_3BO_3
- Molecular Credence: 61.83 g/mol
- Flammability: Non- Combustible.
- Density: Bulkiness of 880 kg/ m^3
- Melting point (^{0}C): 171^{0}C
- Water Solubility: At 20^{0}C, the soaked elucidation is of 4.6% w/w.
- pH value: 3.9
- Structural Formula (is shown in figure 1)
- Appearance: White crystalline granules or powder (is shown in figure 2)

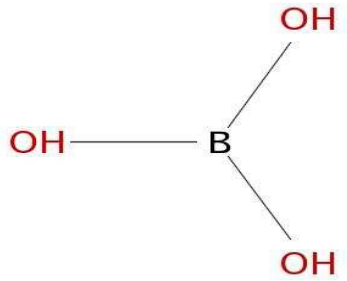

Figure 1. Structural Formula of Boric Acid.

Figure 2. Appearance of Boric Acid.

The nanoparticles of boric acid applications are in wings of medical, preservations, motor oils, lubricants in machining e.t.c. The liquid boric acid waste does not deliver a harsh impact to the environment. By substituting it for the sulfur-containing additives, there are no sulfur deposits to build up in the catalytic converter. The sulfur deposits build up on the surface of the converter so that it eventually can't process any more exhaust and chokes up. The toxic emissions are reduced with the boric acid additive. As a result, the additive cuts the sulfur content released from the car's exhaust into the atmosphere, where it eventually becomes the sulfuric acid component of acid rain. The experimental procedure for synthesis is considered as follows; the pioneer material used for high energy ball milling with high purity boric acid powder. Initially crystalline size of Boric acid is taken for milling is 536nm. The investigational milling time periods were chosen to be 5, 10 and 15 hours. The model is occupied out after every 5 hours of milling for characterize. The experimental details of milling process are shown in table 1.

Table 1. Experimental detailes of milling process.

Mechanical ball milling	Performed at particular room temperature
Milling Container	Tungsten carbide, Zirconium Container
Milling Speed	150 rpm
Total Milling time	15 hrs
Grinding Medium	Toluene (wet grinding)
Ball to Powder Weight Ratio (BPR)	10: 1
Balls Type	Tungsten Carbide (10mm), Zirconium (3mm)

By using ball milling the crystal size of boric acid is successfully reduced to different nanometres based on time period and are shown in table 2.

Table 2. Reduction of Crystal Size with Increasing Ball Milling Hours.

Time(hours)	Crystal Size (nm)
Initial	536
0 to 5	83
5 to 10	65
10 to 15	61

The crystallite range of boric acid is abridged from 536nm to 61nm for a period of 15hrs via using high energy planetary ball mill and in ball milling, toluene is used as grinding medium. The graph below shows the reduction of crystal size with respect to the milling time.

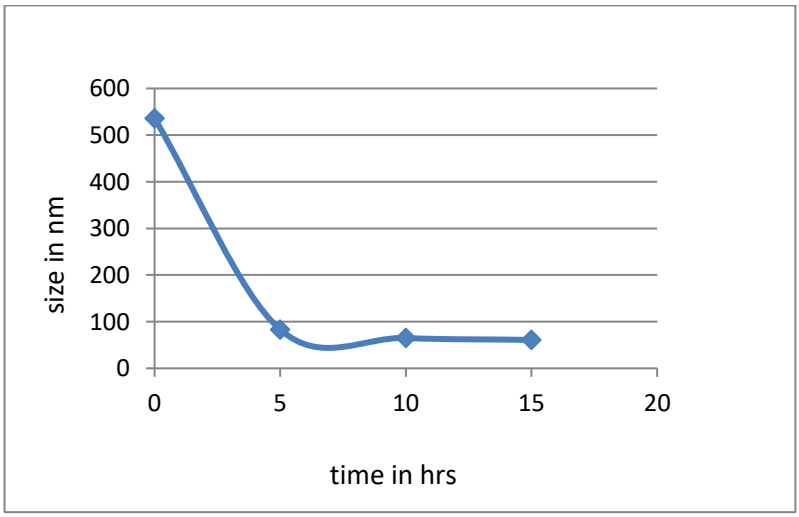

Figure 3. Crystallite Size with Milling Time.

By using X –Ray Diffractometer (XRD), the diffraction methods are Powder Diffraction Method, Laue Diffraction Method and, Rotating Crystal Method.

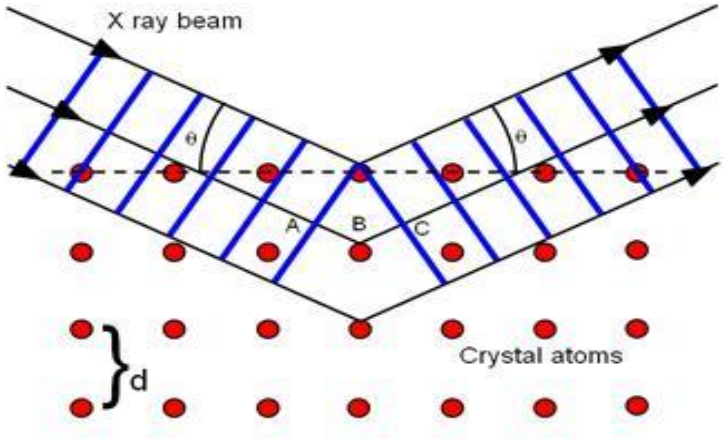

Figure 4. X-ray Diffraction.

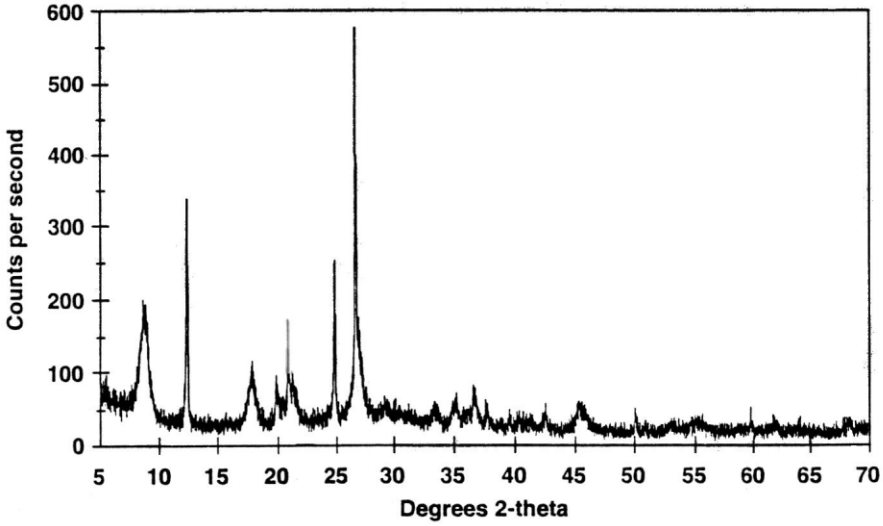

Figure 5. General Example of Diffractogram

Table 3. Crystal Sizes of Boric Acid Particles Obtained From the XRD.

Milling Time (Hours)	2theta	FWHM	Crystal Size(nm)
Initial	28.057	0.197	536
5	28.032	0.155	83
10	28.027	0.153	65
15	28.037	0.184	61

The crystal sizes of boric acid particles obtained from the XRD of different ball milling time is shown in table 4. The figures 6, 7, 8 and, 9 shows the XRD patterns of initial, 5hrs, 10hrs and 15hrs milled powder sample milled in high energy ball mill. From the phase analysis it had been identified that peak intensity increases as ball milling time increases. With boric acid peaks sassolite – H3BO3 at initial and at 5 hrs ball milling, copper titanium borate oxide and sodium bismuth arsenate at 10hr ball milling and titanium borate oxide at 15 hrs ball milling are visible.

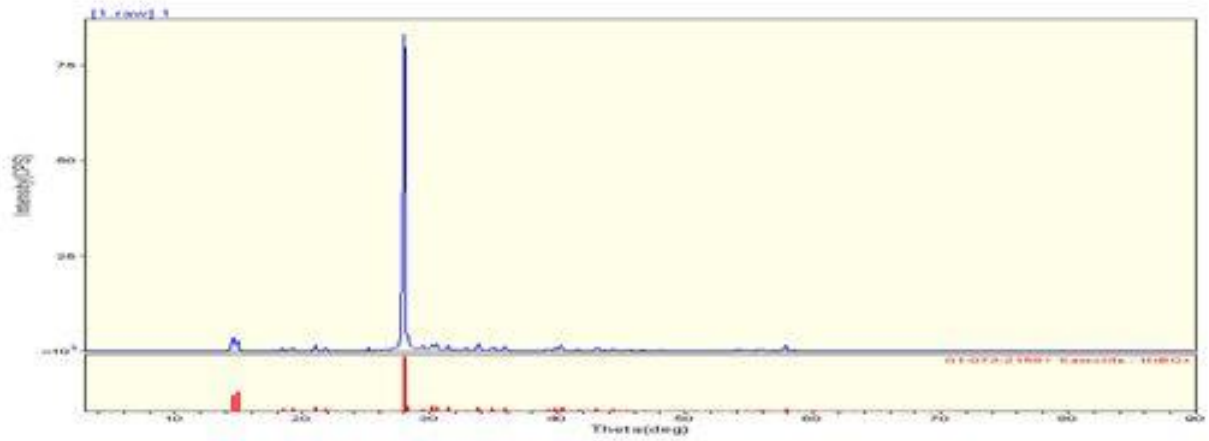

Figure 6. XRD Patterns of initial stage boric acid powder.

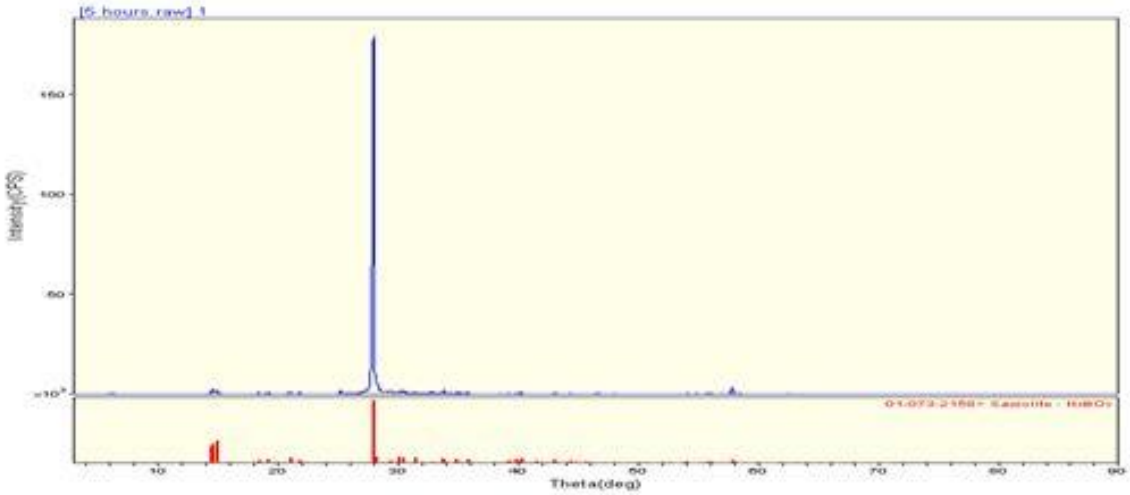

Figure 7. XRD Patterns of 5hr ball milled boric acid powder.

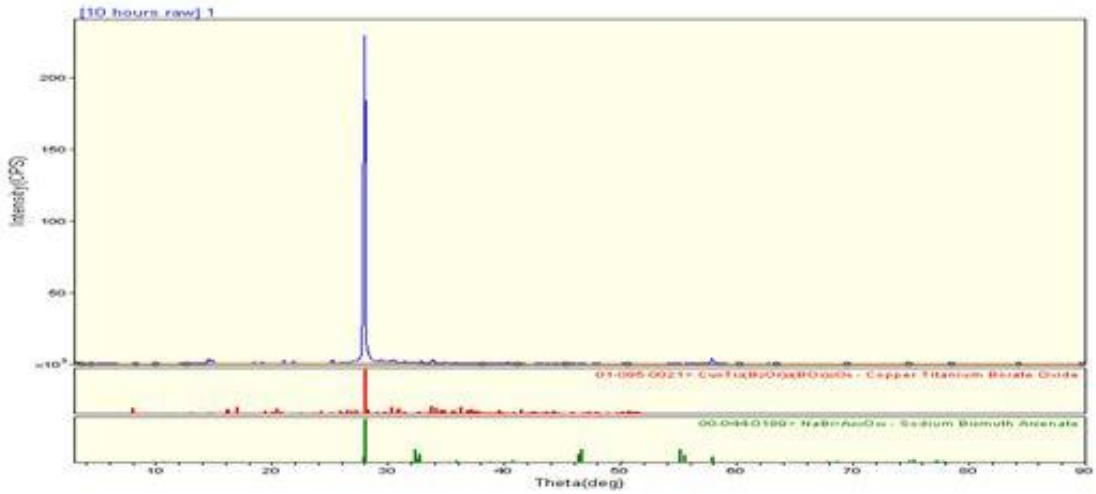

Figure 8. XRD Patterns of 10hr ball milled boric acid powder.

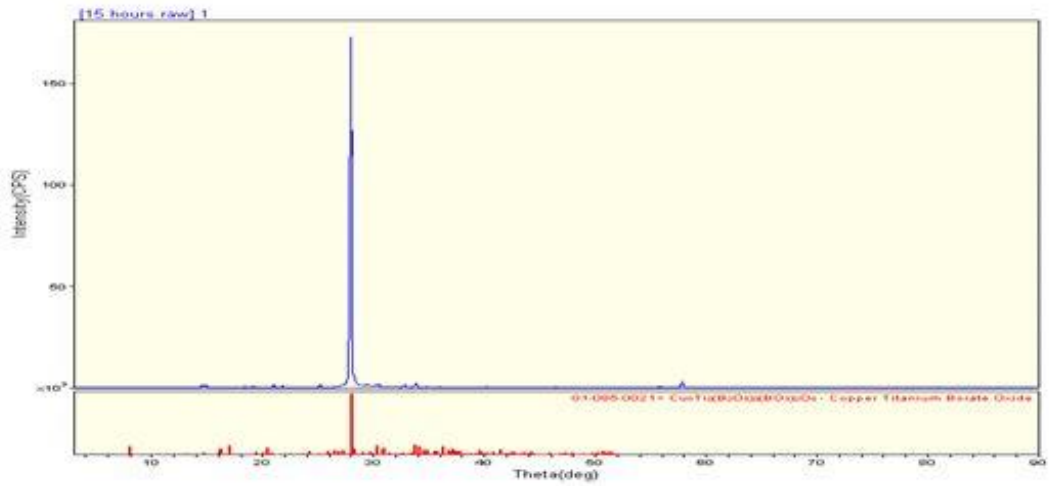

Figure 9. XRD Patterns of 15hr ball milled boric acid powder.

CONCLUSION

The subsequent conclusions are pinched based on the works reported by earlier researchers. It is observed that H3BO3 preparation and synthesis is ecofriendly and can be characterized with modern techniques like XRD. The range lessening of boric acid from 5.6 microns level to 61 nm has been achieved by high-energy mechanical ball milling for the duration of 15hrs. By X-Ray Diffractometer, the Nano structured H3BO3 particle size measurement is done and was supported by Scherer's formula. The XRD of boric acid sample reveal that the necessary stage is at hand with a small quantity of impurities. This boric acid Nanoparticles is now ready for the suspension in the base fluid and then this Nanofluid is used for machining as a lubricant that would give the excellent performance. The base fluids may be water, SAE 40/50, ethylene glycol e.t.c.

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