

# Synthesis, Characterization of Derivatives Synthesized by the Condensation of 7-Bromo-9,9-Dimethyl-9H-Fluorene-2-Carboxylic Acid, Benzo[D]Thiazole-2-Amine, 3-Phenoxy-N-Phenylbenzenamine and Pyridine

## Abstract

A newly synthesized target molecules of N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide, N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-((3-phenoxyphenyl)(phenyl)amino)-9H-fluorene-2-carboxamide, and N-(benzo[d]thiazol-2-yl)-7-((3-hydroxyphenyl)(phenyl)amino)-9,9-dimethyl-9H-fluorene-2-carboxamide have been synthesized by environment friendly and fast microwave assisted technic and checked their in vitro as potential antimicrobials activity. The synthesized molecules showed the good and scenic antimicrobial and anti-inflammatory activity. This method offers several advantages such as mild reaction condition, high yield, and shorter reaction time, and environment friendly, simple experimental procedure.

**Keywords:** Synthesis, Microwave Irradiation, Antimicrobial Activity. Anti-Inflammatory Activity.

## Introduction

Heterocyclic compound is one which accomplishes a cyclic structure with at least two different sorts of hetero atoms in the ring. Heterocyclic compounds are very widely distributed in nature and are necessary to life in various ways. A number of derivatives of heterocyclic compounds containing nitrogen and sulphur atom serve as a comical and mutable scaffolds for experimental drug design [1]. Number of heterocyclic nuclei, such as 1,3,4-thiadiazole, benzimidazole, 1,3,5-triazine, and benzothiazole have been recently powwow as antimicrobial agents [2,3]. In fact, benzothiazole derivatives possess a wide variety spectrum of biological applications such as antitumor, schistosomicidal, anti-inflammatory, anticonvulsant, antidiabetic, antipsychotic, diuretic, and antimicrobial activities [4-6].

2-Aminobenzothiazoles show high reactivity. They have been broadly used as reactants or reaction intermediates since the  $\text{NH}_2$  and endocyclic N functions are suitably situated to enable reactions with common bis electrophilic reagents to form a variety of fused heterocyclic compounds. 2-amino benzothiazole compounds have a wide application and are opined one of an important type of fusedthiazoles. The chemistry of 2-amino benzothiazole compounds has more attention to increasing interest in both synthetic organic chemistry and biological areas [7]. A number of 2-amino benzothiazole derivatives were synthesized by two manners. The first one is Hegersch's method using the reaction of thiourea derivative with bromine in acetic acid. The second one method was using the direct reaction of amine derivatives with potassium thiocyanate and bromine in glacial acetic acid. In 1887 Hoffmann was introduced the cyclizations of 2-amino thiophenol to 2-amino benzothiazole. The formation of 2-anilineobenzothiazole from the reaction of 2-amino thiophenol and phenyl isothiocyanate was noted by Hoffmann.

Some important other methods for synthesise of 2-amino benzothiazole derivatives mentioned by number of researchers i.e. Qiuping, D. et al. obtained 2-N-alkylbenzothiazole using starting material as 2-

## Dalia Manna

Research Scholar,  
Deptt. of Chemistry,  
Bhagwant University,  
Ajmer, Rajasthan, India

## Gajendra Kumar

Associate Professor,  
Deptt. of Chemistry,  
Bhagwant University,  
Ajmer, Rajasthan  
Chemical Science laboratory,  
BIT, Muzaffarnagar, U.P., India

iodobenzenamine and isothiocyanate and catalyze the reaction with copper iodide in the presence of DABCO and toluene as a solvent at 50°C [8]. Tweit, R. C. et al. prepared 2-aminobenzothiazole by the reaction of alkyl isothiocyanate and 2-aminothiol as starting material in the presence of alcohol as a solvent at reflux. Abdul Rauf et al. reported the synthesis of 2-substituted benzothiazoles by the condensation of 2-aminothiophenol with different type of fatty acid chlorides [9]. Benediet *al.* synthesized 2-substituted-benzothiazoles using by palladium catalyzed intramolecularcyclization of *o*-bromophenylthioureas and *o*-bromophenylthioamides. Lebedenko reported that heterocyclization of 1-phenyl thiosemicarbazide 1 with polyphosphoric acid in chlorobenzene afforded 2-aminobenzothiazole [10]. The oxidative cyclization of 4-chloro-2-(trifluoromethyl) phenylthiourea with bromine in chloroform followed by basification with NH<sub>3</sub> to give 6-Chloro-4-(trifluoromethyl)-2-aminobenzothiazole [11-12]. N-(4-nitrobenzothiazol-2-yl) benzamide prepared 1-Benzoyl-3-phenylthiourea was heterocyclized by using a mixture of sodium nitrite and sulphuric acid which has been treatment with 20% H<sub>2</sub>SO<sub>4</sub> and NH<sub>2</sub>SO<sub>3</sub>H led to the formation of 2-amino-4-nitrobenzothiazole [13]. Allen and coworkers have reported that the reaction of *p*-toluidine with sodium thiocyanate in chlorobenzene and in the presence of sulfuric acid gave thiourea. Warming thiourea with sulfuryl chloride at 50° C furnished 2-amino-6-methylbenzothiazole [14].

## Review of Literature

In this present work, the synthesis of substituted N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide, N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-((3-phenoxyphenyl)(phenyl)amino)-9H-fluorene-2-carboxamide, and N-(benzo[d]thiazol-2-yl)-7-((3-hydroxyphenyl)(phenyl)amino)-9,9-dimethyl-9H-fluorene-2-carboxamide using microwave irradiation was investigated. Microwave-Induced Organic Reaction Enhancement (MORE) chemistry has gained popularity as a non-conventional and environmental friendly technique for rapid synthesis of researches have described accelerated organic reactions, and a large number of papers have appeared proving the synthetic utility of MORE chemistry in routine organic synthesis [15-23]. Microwave-assisted organic synthesis could help achieve high yields and clean reaction outcomes at short reaction time. Organic solvent free reaction conditions eliminate the toxicity and flammability issues associated with common solvents. Together, solvent free organic syntheses assisted by microwave irradiation have being regarded as environmentally benign methodologies [24]. In continuation of this research, the aim of study is to synthesize some novel compound of benzo thiazole and checked their antimicrobial and anti-inflammatory activity.

## Experimental Section

### Materials

All compounds and chemicals were purchased from Sigma-Aldrich Chemicals and Merck and used without additional purification. Melting points

were determined using an open-ended capillary tube method and are uncorrected. TLC was performed on pre-coated plastic sheets of silica gel G/UV of 0.2 mm thickness (Macherey-Nagel, Germany). The homogeneity and purity of the synthesized compounds was checked by TLC. A FT-IR spectrum was recorded on a Perkin-Elmer 1605 series FT-IR in a KBr disc. <sup>1</sup>H NMR spectra were recorded at 300 MHz on a Bruker FT-NMR spectrophotometer using TMS as internal standard.

### N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide

A combination reaction of 7-bromo-9,9-dimethyl-9H-fluorene-2-carboxylic acid (0.12mol) and Benzo[d]thiazole-2-amine (20 mL) in the presence of DMSO (65 mL) was assisted by microwave oven for 2-3 minutes at 400 Watts. The obtained mixture was transferred into crushed ice which results in precipitate. The mixture was stirred continuously overnight and filtered it. The crude obtained was dissolved in ethanol (500 ml) and formed slurred, filtered it and then recrystallized from heptane.

The physical and analytical data of C<sub>23</sub>H<sub>17</sub>BrN<sub>2</sub>OS (448.02) calcu. C, 61.48; H, 3.81; N, 6.23; Found: C, 61.43; H, 3.86; N, 6.70, M.P. 266°C. IR (KBr)  $\nu_{max}$  in cm<sup>-1</sup>, 680 cm<sup>-1</sup> (C—Br), 766 cm<sup>-1</sup> (C—C), 1244 cm<sup>-1</sup> (C—N), 1565 cm<sup>-1</sup> (C=N), 3245 cm<sup>-1</sup> (—NH), 1544 cm<sup>-1</sup> (C=C for aromatic compound), 688 cm<sup>-1</sup> (C—S—C), 3055 cm<sup>-1</sup> (C—H for aromatic compound). <sup>1</sup>H NMR (CDCl<sub>3</sub>)  $\delta$  in ppm, 9.30 (s, 1H, —NH of thiazol), 7.65-6.85 (m, 10H, Ar—H), 2.34 (m, 6H, CH<sub>3</sub>), 9.4 (s, H, NH). <sup>13</sup>C NMR in CDCl<sub>3</sub> ppm 168.63, 153.90, 150.58, 143.78, 139.60, 134.87, 130.44, 126.54, 121.77, 69.33, 57.04, 32.88. GCMS (H<sup>+</sup>) m/e 447.02, 382.52, 315.88, 296.40, 246.74, 234.32, 219.31, 212.29, 149.12, 134.20, 111.55, 99.14, 42.12.

### N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-((3-phenoxyphenyl)(phenyl)amino)-9H-fluorene-2-carboxamide

A solution of 3-phenoxy-N-phenylbenzenamine (0.04mol), N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide (0.04mol) and toluene (300mL) was condensed and cooled at room temperature. A mixture of Pd(dba)<sub>2</sub> (0.43 g), dppf (diphenylphosphinoferrrocene) (0.39 g) and sodium t-butoxide (5.40 g) were further added to the solution and it was assisted by microwave oven for 3-4 minutes at 400 Watts and addition of Toluene, then the organic layer was separated out and rinsed off with a saturated solution of sodium chloride and recrystallized from 1:5 ratio of toluene and heptane mixture to furnish product.

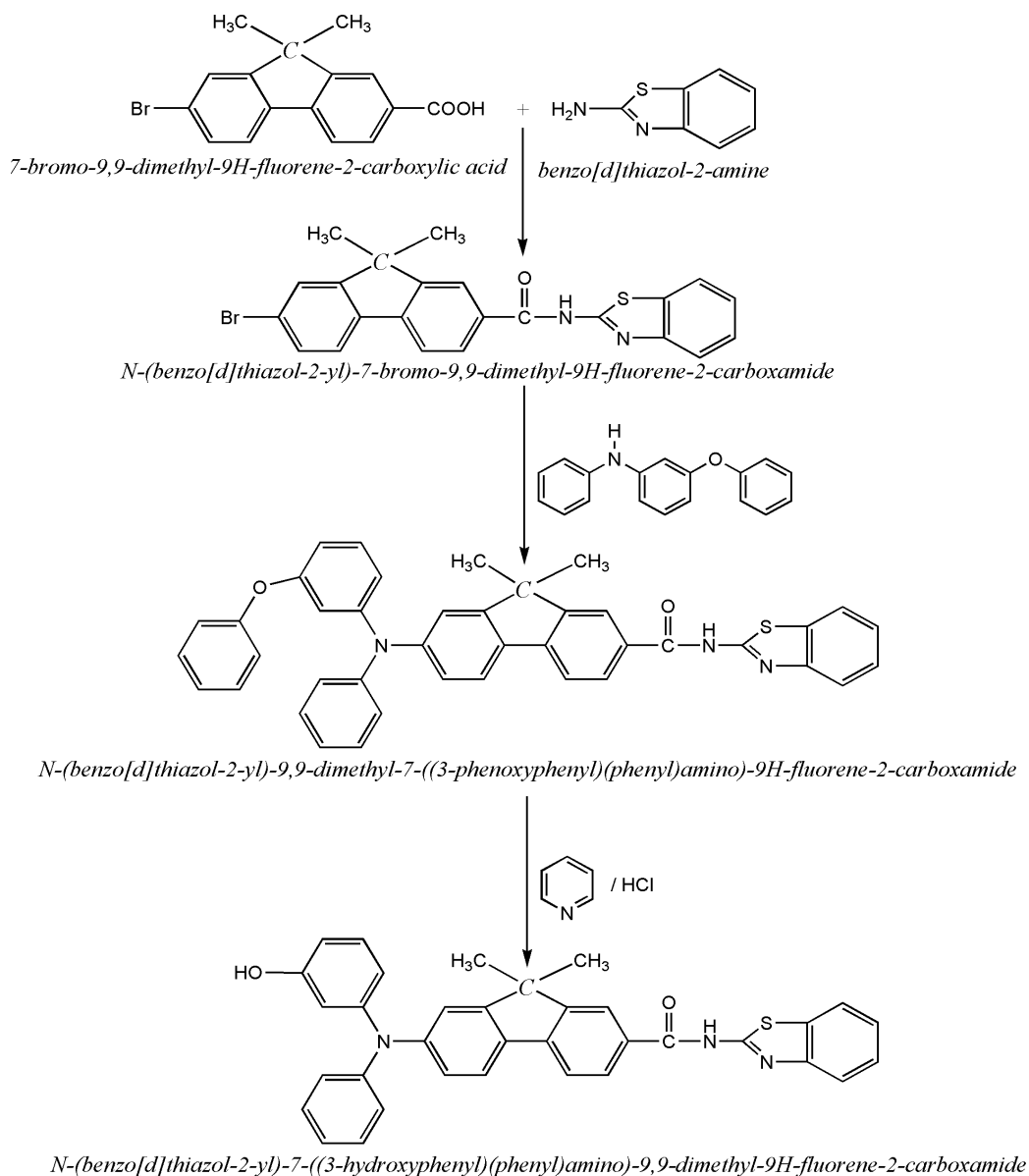
The physical and analytical data of C<sub>41</sub>H<sub>31</sub>N<sub>3</sub>O<sub>2</sub>S (629.21) calcu. C, 78.19; H, 4.96; N, 6.67 Found: C, 78.20; H, 4.94; N, 6.69, M.p. 266°C. IR (KBr)  $\nu_{max}$  in cm<sup>-1</sup>, 685 cm<sup>-1</sup> (C—S—C), 3044 cm<sup>-1</sup> (C—H for aromatic compound), 1575 cm<sup>-1</sup> (C=N), 765 cm<sup>-1</sup> (C—C), 1245 cm<sup>-1</sup> (C—N), 1050 cm<sup>-1</sup> (C—O), 1545 cm<sup>-1</sup> (C=C for aromatic compound). <sup>1</sup>H NMR (CDCl<sub>3</sub>)  $\delta$  in ppm, 9.30 (s, 1H, —NH of thiazol), 7.65-6.85 (m, 24H, Ar—H), 2.34 (m, 6H, CH<sub>3</sub>). <sup>13</sup>C NMR in CDCl<sub>3</sub> 168.63, 153.90, 150.58, 143.78,

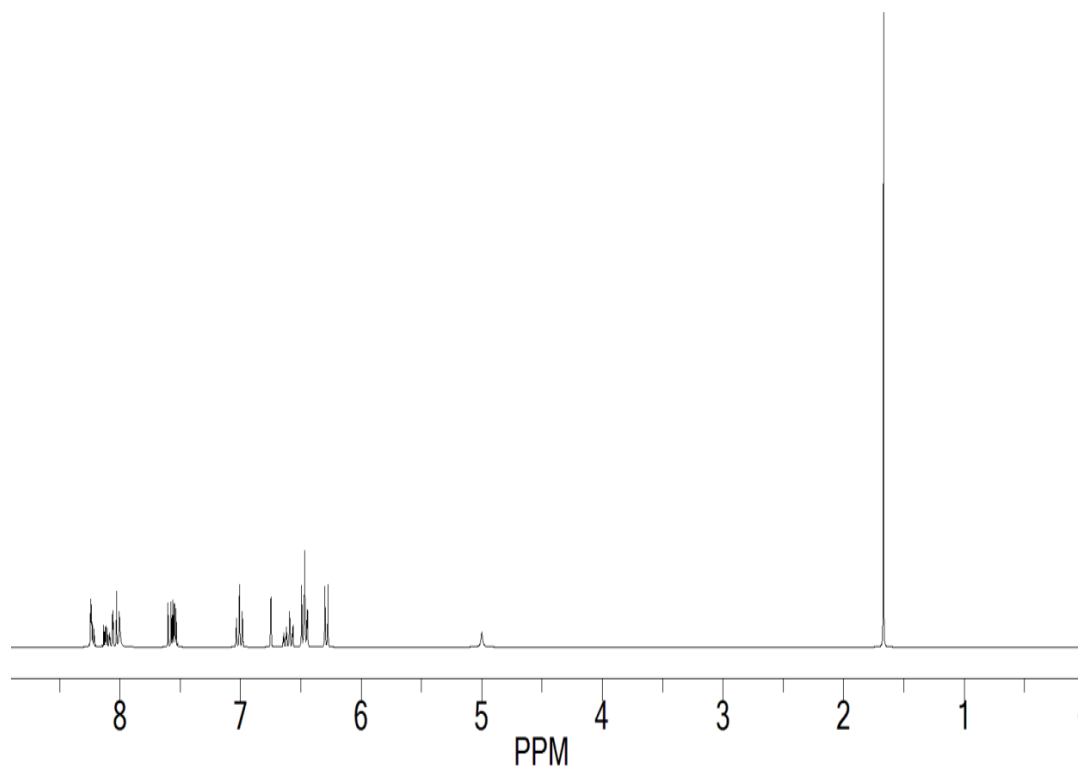
139.60, 134.87, 132.32, 130.44, 129.26, 128.12, 126.54, 125.23, 121.77, 119.34, 116.68, 69.33, 57.04, 32.87. GCMS ( $H^+$ ) m/e 628.21, 592.06, 488.55, 382.52, 315.88, 296.40, 246.74, 234.32, 219.31, 212.29, 149.12, 134.20, 111.55, 99.14, 42.12.

**N-(benzo[d]thiazol-2-yl)-7-((3-hydroxyphenyl)(phenyl) amino)-9, 9-dimethyl-9H-fluorene-2-carboxamide**

A combination reaction of N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-((3-phenoxyphenyl)(phenyl) amino)-9H-fluorene-2-carboxamide (0.19 mol) and pyridine hydrochloride (0.74 mol) was assisted by microwave oven for 3-4 seconds. The reaction mixture was then transferred into warm water, continuously stirred for 30 minutes and then filtered. A slurry of the red precipitate and a dilute ammonium hydroxide solution (5 %) was stirred overnight (20 h), filtered, and the residue was recrystallized from toluene.

The analytical data of compound  $C_{35}H_{27}N_3O_2S$  (553.18) calcu. C, 75.92; H, 4.92; N, 7.59. Found: C, 75.91; H, 4.88; N, 7.62, M.p. 288°C. IR (KBr)  $\nu_{max}$  in  $cm^{-1}$ , 765  $cm^{-1}$  (C—C), 1245  $cm^{-1}$  (C—N), 1545  $cm^{-1}$  (C=C for aromatic compound), 685  $cm^{-1}$  (C—S—C), 3044  $cm^{-1}$  (C—H for aromatic compound), 1575  $cm^{-1}$  (C=N),  $cm^{-1}$  3434 (OH).  $^1H$  NMR ( $CDCl_3$ )  $\delta$  in ppm, 2.35 (m, 6H,  $CH_3$ ), 7.75-6.75 (m, 19H, Ar—H), 9.30 (s, 1H, —NH of thiazol).  $^{13}C$  NMR in  $CDCl_3$  188.63, 169.53, 162.81, 153.90, 150.58, 143.78, 139.60, 134.87, 132.32, 130.44, 129.26, 128.12, 126.54, 125.23, 123.21, 121.77, 119.34, 116.68, 111.24, 88.43, 69.33, 57.04, 32.87. GCMS ( $H^+$ ) m/e 552.18, 488.06, 409.06, 382.52, 356.88, 344.86, 315.88, 296.40, 246.74, 234.32, 219.31, 212.29, 149.12, 134.20, 111.55, 99.14, 42.12.





<sup>1</sup>H NMR Spectra of N-(benzo[d]thiazol-2-yl)-7-((3-hydroxyphenyl)(phenyl)amino)-9,9-dimethyl-9H-fluorene-2-carboxamide

### Results and Discussion

The target compounds were prepared by standard synthetic procedures in different steps. Initially, N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide was synthesized by the combination of 7-bromo-9,9-dimethyl-9H-fluorene-2-carboxylic acid and Benzo[d]thiazole-2-amine in the presence of DMSO was assisted by microwave oven under the above describe manner and used as antimicrobial and anti-inflammatory drugs. Synthesized the N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide compound and proceed the reaction forward to achieve the next target for synthesized the N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-((3-phenoxyphenyl)(phenyl)amino)-9H-fluorene-2-carboxamide by the reaction of 3-hydroxydiphenylamine, N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide and toluene by the assisted microwave in the presence of a mixture of Pd(dba)<sub>2</sub>, dppf (diphenylphosphinoferrocene) and sodium t-butoxide and recrystallized from the mixture of toluene and heptane in 1:5 ratio and used as antimicrobial and anti-inflammatory agent. Next target molecules was prepared from the combination with N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-((3-phenoxyphenyl)(phenyl)amino)-9H-fluorene-2-carboxamide and pyridine hydrochloride assisted by microwave and recrystallized from toluene and check also the antimicrobial and anti-inflammatory activity of the synthesized target molecules and characterized by different analytical tools.

### Antimicrobial Activity

According to the Clinical Laboratory Standards Institute (CLSI) guidelines [23] synthesized molecules such as N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide, N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-((3-phenoxyphenyl)(phenyl)amino)-9H-fluorene-2-carboxamide, and N-(benzo[d]thiazol-2-yl)-7-((3-hydroxyphenyl)(phenyl)amino)-9,9-dimethyl-9H-fluorene-2-carboxamide was screened against Staphylococcus aureus, Pseudomonas aeruginosa, E. faecalis, Escherichia coli and Candida albicans, Candida parapsilosis, Candida tropicalis, Aspergillus niger for using Norfloxacin (NRF) and Fluconazole as reference drug to determine the antibacterial activity and antifungal activity respectively. The experimental results of antibacterial activity [24-26] and antifungal activity of the synthesized molecules articulated as MIC (mg/mL), are listed in Table 1. The antibacterial activity showed a variable degree of efficacy of the synthesized target molecules against different type stain of bacterial. Results showed in table 1, molecules N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide, and N-(benzo[d]thiazol-2-yl)-7-((3-hydroxyphenyl)(phenyl)amino)-9,9-dimethyl-9H-fluorene-2-carboxamide are more effective against staphylococcus aureus, E. faecalis, E. Coli and Pseudomonas as reference drug Norfloxacin. The rest compound N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-((3-phenoxyphenyl)(phenyl)amino)-9H-fluorene-2-carboxamide is equal effective against Staphylococcus aureus like as reference drug and E.

faecalis, E. Coli and Pseudomonas aeruginosa showed moderate activity compared to Norfloxacin. As it seen in Table 1 compounds N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide, N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-(3phenoxyphenyl)(phenyl) amino)-9H-fluorene-2-carboxamide, and N-(benzo[d]thiazol-2-yl)-7-((3-hydroxyphenyl)(phenyl) amino)-9,9-dimethyl-9H-fluorene-2-carboxamide have pronounced antifungal activity and exceed that of fluconazole using as a reference drug for antifungal activity. All synthesized compounds are less effective against the Candida albicans and Candida parapsilosis as reference drug. The results suggest that all synthesized compounds may be worth studying further in terms of their antimicrobial activity.

#### Anti-Inflammatory Activity

In the recent years a number of benzothiazole derivatives have been synthesized and studied to possess anti-inflammatory activity. The activity of newly synthesized target molecules compared to indomethacin as a reference compound was measured before and 4 hours after carrageenan injection. Percent of the oedema inhibition was calculated as regards saline control group and potency was calculated as regards the percentage of the change of Indomethacin as a reference drug and tested molecules, as shown in Table 2. All the tested compounds showed appropriate inhibition of oedema size ranging 49.11% for compound N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide, 65.65% for compound N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-((3

**Table 1 MIC measures for N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide, N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-(3phenoxyphenyl) (phenyl)amino)-9H-fluorene-2-carboxamide, N-(benzo[d]thiazol-2-yl)-7-((3-hydroxyphenyl)(phenyl) amino)-9,9-dimethyl-9H-fluorene-2-carboxamide and reference Drug for antibacterial activity**

Compound	MIC					
	S. Aureus	E. faecalis	E. Coli	P. aeruginosa	C. albicans	C. parapsilosis
N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide,	ME	ME	ME	ME	LE	LE
N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-((3-phenoxyphenyl)(phenyl)amino)-9H-fluorene-2-carboxamide	SE	MdE	MdE	MdE	LE	LE
N-(benzo[d]thiazol-2-yl)-7-(3-hydroxyphenyl)(phenyl) amino)-9,9-dimethyl-9H-fluorene-2-carboxamide	ME	ME	ME	ME	LE	LE
Norfloxacin	62.5	2.95	4.9	62.5	--	--
Fluconazole	--	--	--	--	250	250

NOTE: ME-More effective, LE-Less effective, SE-Same effective, MdE- Moderate effective.

phenoxyphenyl) (phenyl)amino)-9H-fluorene-2-carboxamide, 75.10 % for compound N-(benzo[d]thiazol-2-yl)-7-((3-hydroxyphenyl) (phenyl) amino)-9,9-dimethyl-9H-fluorene-2-carboxamide and 79.62% for Indomethacin using as reference drug. In activity relationship point of view, the anti-inflammatory activity of the N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-((3 phenoxyphenyl)(phenyl)amino)-9H-fluorene-2-carboxamide and N-(benzo[d]thiazol-2-yl)-7-((3-hydroxyphenyl)(phenyl)amino)-9,9-dimethyl-9H-fluorene-2-carboxamide was found to be good anti-inflammatory activity.

#### Conclusion

The penetration of microwave ovens in the pharmaceutical science has becomes very attractive and formed to carry out many transformations of chemicals with greater capacity. At present time, microwave is a major tool for organic synthesis chemistry as the sources of energy and environment friendly [16]. In this present work, we have used microwave for synthesis of targets molecules under the aforesaid described conditions and found the scenic results. The synthesized target molecules have checked and recrystallized under the used of various analytical tools for characterization. The synthesized molecules N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide, N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-((3-phenoxyphenyl) (phenyl)amino)-9H-fluorene-2-carboxamide, and N-(benzo[d]thiazol-2-yl)-7-((3-hydroxyphenyl)(phenyl) amino)-9,9-dimethyl-9H-fluorene-2-carboxamide have been shown good microbial and anti-inflammatory activity.

**Table 2: Anti-inflammatory activity of N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide, N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-((3-phenoxyphenyl)(phenyl)amino)-9H-fluorene-2-carboxamide, N-(benzo[d]thiazol-2-yl)-7-((3-hydroxyphenyl)(phenyl)amino)-9,9-dimethyl-9H-fluorene-2-carboxamide on carrageen an induced oedema of laboratory mice**

Compound	Oedema Volume (ml)			
	Dose (mg/kg)	Zero Min.	4 hour	% Inhibition after 4 hours
Control	Normal saline	29.83±1.23	148.34±2.35	--
N-(benzo[d]thiazol-2-yl)-7-bromo-9,9-dimethyl-9H-fluorene-2-carboxamide,	250 mg/kg	32.23±1.44	75.47±1.22	49.11
N-(benzo[d]thiazol-2-yl)-9,9-dimethyl-7-((3-phenoxyphenyl)(phenyl) amino) -9H-fluorene-2-carboxamide	250 mg/kg	36.83±1.23	50.94±1.42	65.65
N-(benzo[d]thiazol-2-yl)-7-((3-hydroxyphenyl)(phenyl)amino)-9,9-dimethyl-9H-fluorene-2-carboxamide	250 mg/kg	25.33±1.47	36.93±1.22	70.85
Indomethacin	10 mg/kg	27.83±1.72	30.22±1.57	79.62

### Endnotes

- Patel N B, Shaikh F M, New 4-thiazolidinones of nicotinic acid with 2-amino-6 methylbenzothiazole and their biological activity. *Sci Pharm.* 78 (2010) 753-765.
- Sukhbir L K, Arora K, Mehta H, Aggarwal A, Yadav M, Common methods to synthesize benzothiazole derivatives and their medicinal significance: A Review, *International Journal of Pharmaceutical Sciences and Research*, Vol. 2(2011): 1356-1377.
- Patel R V, Patel P K, Kumari P, Rajani D, Chikhaliya KH, Synthesis of benzimidazolyl-1,3,4-oxadiazol-2-ylthio-N-phenyl (benzothiazolyl) acetamides as antibacterial, antifungal and antituberculosis agents, *Eur. J. Med. Chem.* 53 (2012) 41-51.
- Gupta A, Rawat S, Synthesis and Cyclization of Benzothiazole: Review, *J. Curr. Pharm. Res.* 3 (2010) 13-23.
- Alang G, Kaur R, Kaur G, Singh A, Singla P, *Acta Pharm. Sci.* 52 (2010) 213-218.
- Catalano A, Carocci A, Defrenza I, Muraglia M, Carrieri A, Van Bambeke F, Rosato A, FilomenaCorbo Carlo Franchini, 2-Aminobenzothiazole derivatives: Search for new antifungal agents, *European Journal of Medicinal Chemistry* 64 (2013) 357-364.
- Bondock S, Fadaly W, Metwally M A; Recent trends in the chemistry of 2-aminobenzothiazoles, *J. Sulfur Chem.* 2009, 30, 74-107.
- Qiuping D, Xiaodan H, Jie W, Synthesis of 2-Aminobenzothiazole via Copper (I)-Catalyzed Tandem Reaction of 2-Iodobenzenamine with Isothiocyanate; *Journal of combinatorial chemistry*, 11 (2009) 587.
- Rauf A, Gangal S, Sharma S, Zahin M; A Simple, Rapid and Efficient One-pot Protocol for the Synthesis of 2-substituted Benzothiazole Derivatives and their Antimicrobial Screening, *S. Afr. J. Chem.*, 61 (2008) 63-67.
- Lebedenko N Yu; Deposited Doc. (1978) 251-253 (USSR); *Chem. Abstr.* (1980) 92, 94288.
- Leby T, Archana G, Vandana G J; *Jou. Fluorine Chem.* 122 (2003) 207-213.
- Kamel E M, Ragaa A A, Osama S M; *J. Chin. Chem. Soc.* 52 (2005) 149-153
- Malinowsh W, Szadowski T, Kraska, J. *Pol. Pat.* 1996, 165, 691; *Chem. Abstr.* 1996, 125, 275861b.
- Allen C F H, James Coll V A; *Org. Synth.* 3 (1955) 76-79.
- Wang R, Lu X, X. Yu, L. Shi, Y. Sun, Acid-catalyzed solvent-free synthesis of arylbenzimidazoles under microwave irradiation, *J. Mol. Cat. A: Chemical*, 266(2007) 198- 201.
- Ravichandran S, Karthikeyan E, *Microwave Synthesis - A Potential Tool for Green Chemistry*, *International Journal of Chem Tech Research*, 3 1 (2011) 466-470,
- Patra L, Aich K, Gharami S, Mondal T K, A new carbazole-benzothiazole based chemodosimeter for chromogenic and fluorogenic detection of CN<sup>-</sup> *Journal of Luminescence*, 201 (2018) 419-426.
- Kovicova E N, Lorenc D, Magdolen P, Sigmundova L, Zahradnik , Velic D, Broadband two-photon absorption cross sections of benzothiazole derivatives and benzobisthiazolium salts, *Chemical Physics Letters*, 700 (2018) 22-26.
- Tapkir A S, Chitlange S S, Bhole R P; Dataset of 2-(2-(4-aryloxybenzylidene) hydrazinyl) benzothiazole derivatives for QQSAR of antitubercular agents, *Data in Brief* 14 (2017) 469-473.
- Kumar G, Kumar A, Shishodia N, Garg Y P, Yadav B P; Synthesis, spectral characterization and antimicrobial evaluation of schiff base Cu (II), Ni (II) and Co (II) novel macrocyclic complexes, *Journal of Chemistry* 8, 4 (2011)1872-1880.
- Smith J S, Chakraborty I, C.Sameera W M, Mascharak P K; Antimicrobial silver (I) complexes derived from aryl-benzothiazoles as turn-on sensors: Syntheses, properties and density functional studies, *Inorganica Chimica Acta*, 471 (2018) 326-335.

22. Li Y, Qi Hu, Hong Chen C, Xiao-Long Wang, Da-Wen Gao, Performance and microbial community structure in an integrated anaerobic fluidized-bed membrane bioreactor treating synthetic benzothiazole contaminated wastewater, *Bioresource Technology*, 236 (2017) 1-10.
23. Zhang W, Tempest P; Highly efficient microwave-assisted fluorosUgi and post condensation reactions for benzimidazoles and quinoxalinones, *Tetrahedron Letters*, 45 (2004) 6757-6760.
24. Reddy A C, Rao P S, Venkataratnam R V; Fluoro organics: Facile syntheses of novel 2- or 4-trifluoromethyl-1H-arylo-1,5-diazepines, oxazepines, thiazepines, 2-(1,1-trifluoroacetyl)imidazoles, oxazoles and thiazoles, *Tetrahedron*, 53 (1997), 5847-5854.
25. Dabhi T P, Shah V H, Parikh A R; "Studies on s-triazines: preparation and antimicrobial activity of 2,4-diarylamino-6-(benzothiazol-2-ylthio)-s-triazines." *Ind. J. Pharma. Sci.* 54 (1992), 109-111.
26. Kumar G, Devi S, Johari R; Synthesis and spectral characterization of Schiff base Cr (III), Mn (III), and Fe (III) novel macrocyclic complexes derived from thiocarbohydrazide and dicarbonyl compound, *Journal of Chemistry* 9, 4 (2012) 2255-2260.