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# Ultrasound assisted synthesis and pharmacological evaluation of some (*E*)-1,2,3-triphenylprop-2-en-1-ones

Veerendiran MALA,[1] Inbasekaran MUTHUVEL,[2,3] Ganesamoorthy THIRUNARAYANAN[*],[2] Saravanan Palavanivel SAKTHINATHAN,[4] Ranganathan ARULKUMARAN,[4] Venkatesan MANI,[4] Rajasekaran SUNDARARAJAN,[4] Dakshnamoorthy KAMALAKKANNAN,[4] Ramamurthy SURESH,[4] and Veeramalai USHA[5]

[1]*Department of Chemistry, Annai Arts & Science College, Kovilacheri, Kumbakonam-612 503, India*
[2]*Department of Chemistry, Annamalai University, Annamalainagar-608 002, India*
[3]*Department of Chemistry, MR Government Arts College, Mannargudi-614 001, India*
[4]*Postgraduate and Research Department of Chemistry, Government Arts College, C-Mutlur-608102, Chidambaram, India*
[5]*Department of Chemistry, University College of Engineering, Panruti-607 106, India*

**Abstract.** More than 85% yield of (*E*)-1,2,3-triphenylprop-2-en-1-ones were synthesized using disodium hydrogen phosphate ($Na_2HPO_4$) catalyzed ultrasound assisted aldol condensation of 1,2-diphenylethanone and various substituted benzaldehydes. Synthesized (*E*)-1,2,3-triphenylprop-2-en-1-ones were examined by their spectroscopic data, yield, micro analysis and physical constants. The effect of solvent on the yield was investigated. The pharmacological effects such as antibacterial and antifungal activities of synthesized enones were evaluated with Bauer-Kirby disc diffusion method.

***Keywords:*** triphenyl enones; ultrasonication; disodium hydrogen phosphate; aldol condensation; solvent effect; antimicrobial activity.

## 1. Introduction

Now-a-days scientist and chemists paid much more attention to ultrasound assisted organic synthesis due to this technique obeyed twelve principle of green chemistry [1, 2]. Conventional synthetic methods need prolonged time for completion of reaction, required expensive catalysts and lower yield obtained. Due to this inconvenient, ultrasound or microwave irradiation are used as alternate source of energy for applied organic synthesis. Application of ultrasound is very vast visible such as chemical synthesis, bio-leaching, chemical leaching of metals and non-metals, polymer degradation, polymerization, luminance, bio-metabolites production and bio-degradation [3, 4]. In industrial views, ultrasound was used for cleaning, welding of melts and plastics, cutting, forming separating, degassing, mixing localizing and atomizing [5]. About 20-100 kHz frequency range of ultrasound was utilized for microbial growth and 24-25 kHz frequency range of ultrasound was suitable for biodegradation and fermentation. Sonication at 1 MHz is suitable for electron spin resonance study with free radicals. Nucleation of protein was done with 100 kHz frequency range of ultrasound. About 0.02 – 20 MHz frequency range of ultrasound was used to therapeutics and enhancement of microbial enzymatic activities [6, 7]. Enones are important basic units for organic building construction, pharmaceutical and industrial applications including non-corrosiveness [8, 9]. Enones exhibits *s-cis* and *s-trans* conformers and possessing *E* and *Z* configurations. These structural conformations are confirmed by infrared and nuclear magnetic resonance spectroscopy [8, 10]. Numerous catalysts employed for ultrasound assisted organic synthesis such as Lewis acids for synthesis of pyrimidine [11], Pd/C assisted Heck reaction for alkenes[12], palladium acetate and Cu assisted biphenyl and heterocycle synthesis [13, 14], $Pd(PPh_3)_4$ catalyst used for alkene synthesis by cross coupling reaction [15], $PdCl_2$ catalyst applied for synthesis of alkenes including ferrocenyl alkenes through Sonogashira coupling [16], phase transfer catalyst employed for amino acid synthesis by Strecker technique [17], Mg metal assisted trimethyl silane synthesis [18], $Zn/CH_2I_2$ and NaOH assisted cyclopropanation of alkenes [19], $I_2$ in Zn dust catalyst for β-hydroxy esters [20], $Al_2O_3$-KCN supported Diels-Alder arylation [21], sulphamic acid catalyzed β-aminocarbonyl compound synthesis [22], Li catalyzed naphthol synthesis from *o*-allyal benzamides [23] and ZSM-5 zeolite catalyzed acrolein synthesis by dehydration of glycerol [24]. Recently, Usha et al. reported good yields of 3-chloro-4-nitrophenyl chalcones synthesized by NaOH catalyzed ultrasound assisted aldol condensation [25]. Literature review shows that, there is no report availed for disodium hydrogen phosphate ($Na_2HPO_4$) catalyzed ultrasound assisted synthesis of (*E*)-1,2,3-triphenylprop-2-en-1-ones in the past. Hence, the authors taken efforts for the

[*] Corresponding author. *E-mail address*: drgtnarayanan@gmail.com (G. Thirunarayanan)

synthesis of above enones and studied the pharmacological effects by Bauer-Kirby [26] disc diffusion method.

## 2. Experimental

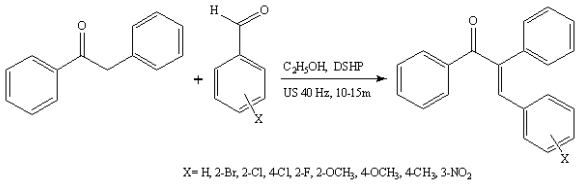
### *2.1. Materials and methods*

Chemicals and solvents used in this research work were procured from Sigma-Aldrich Chemical company Bangalore India. Nutrient broth, Mueller Hinton agar, potato dextrose agar, Tween-80 solution and other materials required have been purchased from Himedia, Mumbai, India. Melting points of synthesized enones are found in Raga Tech. make electrical melting point apparatus and are uncorrected. The UV $\lambda_{max}$ (nm) absorption was measured in spectral grade methanol using Shimadzu-1650 UV spectrophotometer. Avatar–Nicolet-330 FT-IR spectrophotometer was used for recording infrared spectra of all enones in KBr discs. NMR Spectra of all α, β-unsaturated ketones under investigation were recorded using Bruker 400MHz Spectrometer. Frequencies range of 400 and 125 MHz was applied for recording $^{1}H$ and $^{13}C$ spectra in deuterated $CDCl_3$ solvent and TMS as standard. Thermo Fennigan CHN analyzer was used for micro analysis estimation. Shimadzu mass spectrometer was used for recording mass spectra of all compounds.

Microorganisms such as *Bacillus subtilis, Micrococcus luteus, Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa, Aspergillus niger* and *Trichoderma viride* were received and maintained at the Research laboratory, Post Graduate and Research Department of Chemistry, Government Arts and Science College, Chidambaram. Ampicillin and Michanazole are employed as standard drug for this measurement. The stock cultures have been stored in the cooler machine for further studies.

### *2.2. General procedure for synthesis of (E)-1,2,3-triphenylprop-2-en-1-ones*

A mixture of equimolar quantities of substituted benzaldehydes (1 mmol) and 1,2-diphenylethanone (1 mmol), 1 M $Na_2HPO_4$ (0.3 mL) and 10 mL of ethanol were ultrasonication in ultrasound bath at 40 Hz (Citizen Ultra Sonicator, 40 Hz, 120W, 240V, AC) for 10-15 minutes (Scheme 1) in room temperature. After the completion of the reaction, as monitored by thin layer chromatogram, the resulting precipitate was filtered and washed with cold water. The product appeared as pale-yellow solid. Then this was recrystallized using ethanol afforded glittering solids and kept in a desiccator.




**Scheme 1.** Synthesis of (*E*)-1,2,3-triphenylprop-2-en-1-ones by ultrasonication.

### *2.3. Evaluation of antimicrobial activities*

Antimicrobial activities such as antibacterial and antifungal activities of synthesized (*E*)-1,2,3-triphenylprop-2-en-1-ones were measured using the standard Bauer-Kirby [26] disc diffusion method by means of measurement of the diameter (mm) of zone of inhibition as reported in our earlier work [27].

## 3. Results and discussion

In our synthetic organic chemistry research laboratory, we attempt to synthesis some (*E*)-1,2,3-triphenylprop-2-en-1-ones by ultrasonicated aldol condensation of 1,2-diphenylethanone and substituted benzaldehydes in presence of $Na_2HPO_4$. In this condensation, electron-donating substituted benzaldehydes gave higher yields than electron-withdrawing substituted benzaldehydes. For this condensation, the authors studied the effect of solvents on the yield in both ultrasonication and conventional heating method. Various solvents such as acetonitrile, dichloromethane, dioxane, ethanol, methanol and tetrahydrofuran employed in this condensation under the same condition as mentioned in the experimental section. Both the methods, ethanol medium gave higher yields than other solvents. Dioxane and acetonitrile medium gave lower yields in ultrasonication and conventional heating methods.

**Table 1.** Effect of solvents on the yields (%) in ultrasonication and conventional heating aldol-condensation methods.

| Entry | X | ACN | | DCM | | DO | | EtOH | | MeOH | | THF | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | USM | CHM | USM | CHM | USM | CHM | USM | CHM | USM | CHM | USM | CHM |
| **1** | **H** | 66 | 44 | 72 | 56 | 63 | 52 | 86 | 74 | 73 | 58 | 74 | 69 |
| **2** | **2-Br** | 64 | 40 | 69 | 52 | 60 | 52 | 81 | 76 | 68 | 50 | 72 | 68 |
| **3** | **2-Cl** | 64 | 46 | 68 | 57 | 62 | 48 | 82 | 75 | 69 | 54 | 73 | 70 |
| **4** | **4-Cl** | 61 | 44 | 68 | 56 | 54 | 47 | 84 | 71 | 69 | 53 | 70 | 67 |
| **5** | **2-F** | 62 | 41 | 70 | 58 | 60 | 53 | 82 | 70 | 68 | 50 | 69 | 66 |
| **6** | **2-$OCH_3$** | 68 | 45 | 76 | 61 | 58 | 49 | 88 | 80 | 74 | 59 | 77 | 73 |
| **7** | **4-$OCH_3$** | 68 | 44 | 75 | 61 | 60 | 52 | 87 | 79 | 74 | 58 | 76 | 72 |
| **8** | **4-$CH_3$** | 62 | 43 | 73 | 59 | 55 | 46 | 85 | 77 | 71 | 57 | 74 | 71 |
| **9** | **3-$NO_2$** | 44 | 37 | 55 | 41 | 40 | 38 | 80 | 69 | 63 | 46 | 67 | 65 |

ACN: Acetonitrile; DM: Dichloromethane; DO: Dioxane; EtOH: Ethanol; MeOH: Methanol; THF: Tetrahydrofuran
USM: Ultrasonication method (Time: 10-15 minutes); CHM: Conventional heating method (Time: 5 hours)

The effect of solvents on the yield was presented in Table 1. Both the methods gave more than 37% yields. From this observation, $Na_2HPO_4$ is suitable catalyst for the aldol-condensation of substituted benzaldehydes and 1,2-diphenylethanone. All synthesized enones were characterized by their physico-chemical constants, yield, micro analysis and spectroscopic data. From the infrared spectra, the ν*CO s-cis* and *s-trans* stretches of enones absorbed in the frequency range of 1691.16 - 1594.62 $cm^{-1}$ and corresponding conformers are shown in Figure 1.

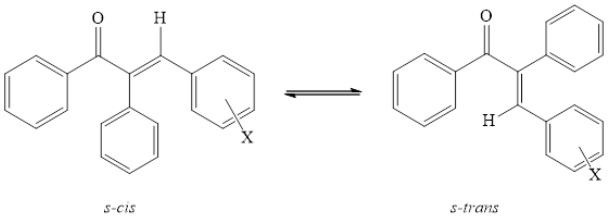



**Figure 1.** The *s-cis* and *s-trans* conformers of (*E*)-1,2,3-triphenylprop-2-en-1-ones.

Similarly, the deformation modes of $\nu CH_{ip}$, $CH_{op}$ and $C{=}C_{op}$ stretches absorbed in the frequency ranges of 1089.78 - 1179.82, 756.21 - 761.88 and 495.71 - 569.75 $cm^{-1}$. The chemical shifts $\delta H_\beta$ proton of all enones obtained in the range of 7.511 - 8.53 ppm. The chemical shifts of δCO, $C_\alpha$ and $C_\beta$ carbons of (*E*)-1,2,3-triphenylprop-2-en-1-ones appeared in the range of 197.04 - 202.83, 133.07 - 137.35 and 139.47 - 142.29 ppm. The complete characterization data of synthesized (*E*)-1,2,3-triphenylprop-2-en-1-ones (**1-9**) are furnished as below.

**(*E*)-1,2,3-Triphenylprop-2-en-1-one (1):** Pale yellow glittering solid; Yield: 86%; m.p. 103-104 (100-101) °C [28]; UV $\lambda_{max}$ (nm): 296; IR (ν, $cm^{-1}$): 1668.43 ($CO_{s\text{-}cis}$), 1597.06 ($CO_{s\text{-}trans}$), 1089.78 ($CH_{ip}$), 761.88 ($CH_{op}$), 495.71 ($C{=}C_{op}$); $^1$H NMR (δ, ppm): 7.051 (s, 1H, $H_\beta$), 6.944 - 7.492 (m, 15H, Ar-H); $^{13}$H NMR (δ, ppm): 197.04 (CO), 134.07 ($C_\alpha$), 140.09 ($C_\beta$), 125.73 - 139.93 (Ar-C); Anal (%). Calcd. for M.F. $C_{21}H_{16}O$ (284): C, 88.70; H, 5.57. Found: C, 88.73; H, 5.52; Mass (m/z): 284 [$M^+$], 207, 179, 130, 118, 105, 102, 91, 77, 53, 41, 28, 24.

**(*E*)-3-(2-Bromophenyl)-1,2-diphenylprop-2-en-1-one(2):** Yellow solid; Yield: 81%; m.p. 90-91 °C; UV $\lambda_{max}$ (nm): 330; IR (ν, $cm^{-1}$): 1654.35 ($CO_{s\text{-}cis}$), 1594.62 ($CO_{s\text{-}trans}$), 1173.31 ($CH_{ip}$), 760.54 ($CH_{op}$), 569.65 ($C{=}C_{op}$); $^1$H NMR (δ, ppm): 7.713 (s, 1H, $H_\beta$), 7.023-7.504 (m, 14H, Ar-H); $^{13}$H NMR (δ, ppm): 196.05 (CO), 136.022 ($C_\alpha$), 141.99 ($C_\beta$), 124.33-138.90 (Ar-C); Anal (%). Calcd. for M.F. $C_{21}H_{15}BrO$ (363): C, 69.44; H, 4.16. Found: C, 69.46; H, 4.12; Mass (m/z): 363[$M^+$], 365 [$M^{2+}$], 285, 283, 257, 207, 180, 178, 168, 156, 130, 118, 105, 102, 91, 77, 53, 41, 28, 24.

**(*E*)-3-(2-Chlorophenyl)-1,2-diphenylprop-2-en-1-one(3):** Pale yellow solid; Yield: 82%; m.p. 76-77 °C; UV $\lambda_{max}$ (nm): 298; IR (ν, $cm^{-1}$): 1653.23 ($CO_{s\text{-}cis}$), 1594.92 ($CO_{s\text{-}trans}$), 1176.65 ($CH_{ip}$), 756.62 ($CH_{op}$), 547.22 ($C{=}C_{op}$); $^1$H NMR (δ, ppm): 8.053 (s, 1H, $H_\beta$), 7.431-7.792 (m, 14H, Ar-H); $^{13}$H NMR (δ, ppm): 197.46 (CO), 133.82 ($C_\alpha$), 142.29 ($C_\beta$), 125.03-139.83 (Ar-C); Anal (%). Calcd. for M.F. $C_{21}H_{15}ClO$ (319): C, 79.12; H, 4.74. Found: C, 79.08; H, 4.71; Mass (m/z): 319 [$M^+$], 321 [$M^{2+}$], 283, 213, 207, 194, 164, 124, 111,102, 91, 77, 53, 41, 35, 28, 24.

**(*E*)-3-(4-Chlorophenyl)-1,2-diphenylprop-2-en-1-one(4):** Pale yellow solid; Yield: 84%; m.p. 76-77 °C; UV $\lambda_{max}$ (nm): 304; IR (ν, $cm^{-1}$): 1646.12 ($CO_{s\text{-}cis}$), 1618.54 ($CO_{s\text{-}trans}$), 1179.82 ($CH_{ip}$), 757.12 ($CH_{op}$), 567.63 ($C{=}C_{op}$); $^1$H NMR (δ, ppm): 7.871 (s, 1H, $H_\beta$), 7.031-7.791 (m, 14H, Ar-H); $^{13}$H NMR (δ, ppm): 197.13 (CO), 133.07 ($C_\alpha$), 142.30 ($C_\beta$), 123.230-139.905 (Ar-C); Anal (%). Calcd. for M.F. $C_{21}H_{15}ClO$ (319): C, 79.12; H, 4.74. Found: C, 79.16; H, 4.69; Mass (m/z): 319 [$M^+$], 321 [$M^{2+}$], 283, 241, 213, 207, 194, 164, 154, 124, 111, 105, 102, 91, 77, 53, 41, 35, 28, 24.

**(*E*)-3-(2-Fluorophenyl)-1,2-diphenylprop-2-en-1-one(5):** Pale yellow solid; Yield: 82%; m.p. 81-82 °C; UV $\lambda_{max}$ (nm): 311; IR (ν, $cm^{-1}$): 1674.32 ($CO_{s\text{-}cis}$), 1648.37( $CO_{s\text{-}trans}$), 1176.41 ($CH_{ip}$), 758.75 ($CH_{op}$), 548.04 ($C{=}C_{op}$); $^1$H NMR(δ, ppm): 7.734 (s, 1H, $H_\beta$), 7.183-7.7102 (m, 14H, Ar-H); $^{13}$H NMR (δ, ppm): 202.83 (CO), 137.35 ($C_\alpha$), 140.68 ($C_\beta$), 124.11-139.02 (Ar-C); Anal(%). Calcd. for M.F. $C_{21}H_{15}FO$ (302): C, 83.43; H, 5.00. Found: C, 83.46; H, 4.94; Mass (m/z): 302 [$M^+$], 304 [$M^{2+}$], 285, 225,207, 197, 194, 178, 148, 108, 105, 102, 95, 91, 77, 53,48, 24, 19

**(*E*)-3-(2-Methoxyphenyl)-1,2-diphenylprop-2-en-1-one (6):** Pale yellow solid; Yield: 88%; m.p. 189-190 °C; UV $\lambda_{max}$ (nm): 330; IR (ν, $cm^{-1}$): 1667.28 ($CO_{s\text{-}cis}$), 1644.62 ($CO_{s\text{-}trans}$), 1177.68 ($CH_{ip}$), 752.65 ($CH_{op}$), 525.56($C{=}C_{op}$); $^1$H NMR (δ, ppm): 7.921 (s, 1H, $H_\beta$), 1.832 (s, 3H, $OCH_3$), 7.262-7.790 (m, 14H, Ar-H); $^{13}$H NMR (δ, ppm): 198.21 (CO), 133.71 ($C_\alpha$), 141.54 ($C_\beta$), 64.38 ($OCH_3$), 124.02-137.92 (Ar-C); Anal(%). Calcd. for M.F. $C_{22}H_{18}O_2$ (314): C, 84.05; H, 5.77. Found: C, 84.12; H, 5.72; Mass (m/z): 314 [$M^+$], 299, 283, 207, 194, 132, 120, 107, 105, 91, 77, 53, 48, 31, 24, 15

**(*E*)-3-(4-Methoxyphenyl)-1,2-diphenylprop-2-en-1-one(7):** Pale yellow solid; Yield: 87%; m.p. 180-181 °C; UV $\lambda_{max}$ (nm): 325; IR (ν, $cm^{-1}$): 1691.16 ($CO_{s\text{-}cis}$), 1664.49 ($CO_{s\text{-}trans}$), 1176.47 ($CH_{ip}$), 753.43 ($CH_{op}$), 548.79 ($C{=}C_{op}$); $^1$H NMR (δ, ppm): 7.952 (s, 1H, $H_\beta$), 1.824 (s, 3H, $OCH_3$), 7.213-7.780 (m, 14H, Ar-H); $^{13}$H NMR (δ, ppm): 202.87 (CO), 136.63 ($C_\alpha$), 141.07 ($C_\beta$), 64.51 ($OCH_3$), 123.22-139.90 (Ar-C); Anal (%). Calcd. for M.F. $C_{22}H_{18}O_2$ (314): C, 84.05; H, 5.77. Found: C, 84.07; H, 5.70; Mass (m/z): 314 [$M^+$], 299, 283, 237, 209, 207, 194, 160, 132, 120, 107, 105, 91, 89, 77, 53, 48, 31, 24, 15

**(*E*)-3-(4-methylphenyl)-1,2-diphenylprop-2-en-1-one(8):** Yellow solid; Yield: 85%; m.p. 118-119 °C; UV $\lambda_{max}$ (nm): 299; IR (ν, $cm^{-1}$): 1654.14 ($CO_{s\text{-}cis}$), 1630.87 ($CO_{s\text{-}trans}$), 1112.92 ($CH_{ip}$), 756.21 ($CH_{op}$), 559.26 ($C{=}C_{op}$); $^1$H NMR (δ, ppm): 7.536 (s, 1H, $H_\beta$), 2.064 (s, 3H, $CH_3$), 7.012-7.487 (m, 14H, Ar-H); $^{13}$H NMR (δ, ppm): 1697.86 (CO), 136.85 ($C_\alpha$), 141.36 ($C_\beta$), 24.91 ($CH_3$), 123.22-139.90 (Ar-C); Anal (%). Calcd. for M.F. $C_{22}H_{18}O$ (298): C, 88.56; H, 6.08. Found: C, 88.52; H, 6.02; Mass (m/z): 298 [$M^+$], 283, 221, 207, 193, 134, 117, 105, 104, 91, 77, 53, 48, 24, 15

**(*E*)-3-(3-nitrorophenyl)-1,2-diphenylprop-2-en-1-one(9):** Yellow solid; Yield: 80%; m.p. 120-212°C; UV $\lambda_{max}$ (nm): 320; IR (ν, $cm^{-1}$): 1672.39 ($CO_{s\text{-}cis}$), 1642.75 ($CO_{s\text{-}trans}$), 1174.23 ($CH_{ip}$), 756.32 ($CH_{op}$), 542.91 ($C{=}C_{op}$); $^1$H NMR (δ, ppm): 7.821 (s, 1H, $H_\beta$), 7.254-7.763 (m, 14H, Ar-H); $^{13}$H NMR (δ, ppm): 199.75 (CO), 134.07 ($C_\alpha$), 139.47 ($C_\beta$), 124.70-138.90 (Ar-C); Anal(%). Calcd. for M.F. $C_{21}H_{15}NO_3$ (329): C, 76.58; H, 4.59; N, 4.25. Found: C, 76.62; H, 4.53; N, 4.19; Mass (m/z): 329 [$M^+$], 283, 252, 224, 207, 194, 178, 135, 122, 105, 104, 91, 77, 54, 48, 24.

### *3.1. Antibacterial activity*

The measured antibacterial activities of substituted (*E*)-1,2,3-triphenylprop-2-en-1-one compounds are shown in Figure 2.

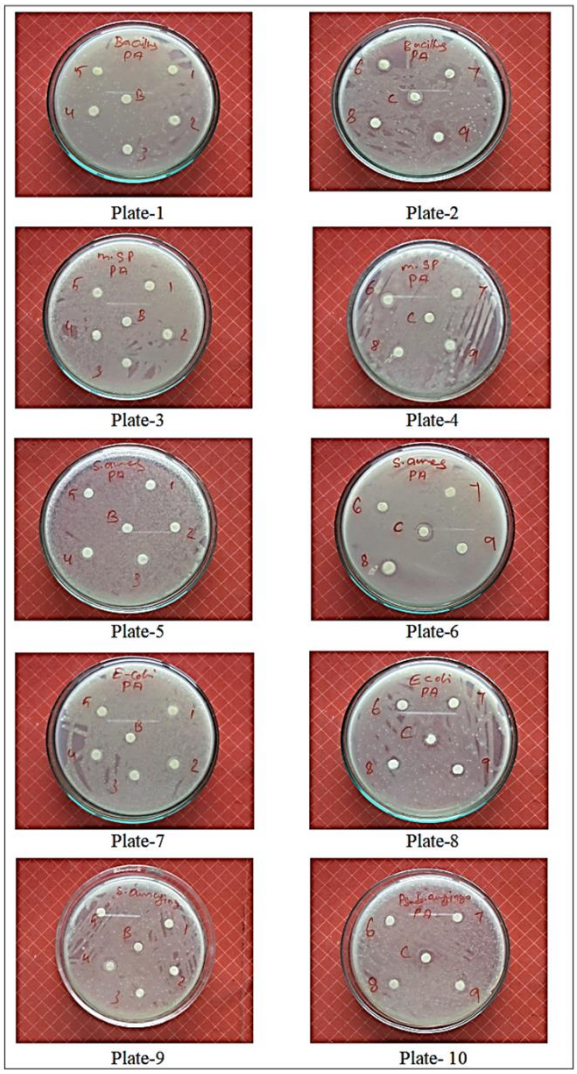



**Figure 2.** Antibacterial activities of (*E*)-1,2,3-triphenylprop-2-en-1-ones on Petri plates.

The diameter of zone of inhibition (mm) values of antibacterial activity is given in Table 2.

**Table 2.** Measured antibacterial activities (diameter of zone of inhibition) of (*E*)-1,2,3-triphenylprop-2-en-1-ones

| Entry | X | Zone of inhibition (mm) | | | | |
|---|---|---|---|---|---|---|
| | | Gram positive bacteria | | | Gram negative bacteria | |
| | | *B. subtilis* | *M. luteus* | *S. aureus* | *E. coli* | *P. aeruginosa* |
| 1 | H | 6 | - | - | 7 | 7 |
| 2 | 2-Br | - | 6 | 6 | 7 | - |
| 3 | 2-Cl | 8 | 8 | 8 | - | - |
| 4 | 4-Cl | - | - | 7 | 7 | 8 |
| 5 | 2-F | 7 | 6 | 6 | - | - |
| 6 | 4-$CH_3$ | 10 | 7 | - | 7 | 7 |
| 7 | 2-$OCH_3$ | 9 | - | 6 | 7 | 7 |
| 8 | 4-$OCH_3$ | 7 | 7 | 8 | 9 | 8 |
| 9 | 3-$NO_2$ | 9 | 8 | 9 | 8 | 10 |
| Standard | Ampicillin | 14 | 12 | 12 | 11 | 13 |
| Control | DMSO | - | - | - | - | - |

Analysis of the zone of inhibition diameter values reveals that the 4-$CH_3$ substituted compounds shown good antibacterial activity against *B. subtilis* strain. Here the mesomeric and hyper conjugation effects of methyl group enhance the antibacterial activity.

Six more compounds with H (parent), 2-Cl, 2-F, 2-$OCH_3$, 4-$OCH_3$ and 3-$NO_2$ substituents have shown moderate antibacterial activity. Here the +I, -I and F electronegativity of substituents were slightly influences their effects.

Remaining enones have shown poor antibacterial activity. The (*E*)-1,2,3-triphenylprop-2-en-1-ones with 2-Br, 2-Cl, 2-F, 4-$CH_3$, 4-$OCH_3$ and 3-$NO_2$ substituents have shown moderate antibacterial activity against *Micrococcus luteus* stain as similar with above.

The parent (H), 2-$OCH_3$ and 4-$CH_3$ substituents shows poor antibacterial activity. Here the mesomeric effect was completely absent.

The enone with 3-$NO_2$ substituent has shown good antibacterial activity against *Staphylococcus aureus* stain. Here the +I effect of the nitro group enhance the antibacterial activity.

Compounds with 2-Br, 2-Cl, 4-Cl, 2-F, 2-$OCH_3$ and 4-$OCH_3$ substituents have shown moderate antibacterial activity. The parent H and 4-$CH_3$ substituted enones shows poor antibacterial activity. This means that the mesomeric and hyper conjugation effects of methyl group was dies off completely.

The 4-$OCH_3$ substituted enone shows good antibacterial activity against *Escherichia coli* stain. Here the +R effect of methoxy group enhances the antibacterial activity.

Compounds with H (parent), 2-Br, 4-Cl, 4-$CH_3$, 2-$OCH_3$ and 3-$NO_2$ substituents have shown moderate antibacterial activity. The 2-F and 4-$CH_3$ substituted enones have no antibacterial activity. This is due to the absence of F, electronegativity, mesomeric and hyper conjugative effects of methyl groups.

The 3-$NO_2$ substituted compound showed good antibacterial activity against *Pseudomonas aeruginosa* stain. The H (parent), 4-Cl, 4-$CH_3$, 2-$OCH_3$ and 4-$OCH_3$ substituted compounds have shown moderate antibacterial activity. The enones containing 2-F and 4-$CH_3$ substituents no antibacterial activity and the reason is already stated earlier.

### *3.2. Antifungal activity*

The antifungal activities of the substituted (*E*)-1,2,3-triphenylprop-2-en-1-one compounds are shown in Figure 3.

The diameter of zone of inhibition (mm) values of antifungal activity is given in Table 3.

Analysis of the diameter of zone of inhibition values reveals that the compounds with H (parent), 2-Br, 2-Cl, 2-F, 4-$CH_3$, 4-$OCH_3$ and 3-$NO_2$ substituents have shown moderate antifungal activity against *Aspergillus niger* stain. Here the electronic effects of the substituents such as inductive, electronegative, field and resonance are not delicately reflected. The 4-Cl and 4-$CH_3$ substituted compounds are inactive and this is due to the +I effect of chlorine atom, hypercoagulation and mesomeric effects of methyl groups are absent.

Synthesized (*E*)-1,2,3-triphenylprop-2-en-1-ones with 2-Cl and 4-Cl substituents have shown good antifungal activity. Here, the +I effect of the choro-

substituents actively enhanced the antifungal activity against *Trichoderma viride* fungal stain.

Compounds with 2-Br, 2-F, 4-$CH_3$, 4-$OCH_3$ and 3-$NO_2$ substituents shows moderate antifungal activity. This is due to the inductive, F, electronegativity, hyper conjugation, mesomeric and resonance effects of the substituents are slightly active. The parent H and 4-$OCH_3$ substituted ketones inactive and the reason for inactiveness is stated earlier.

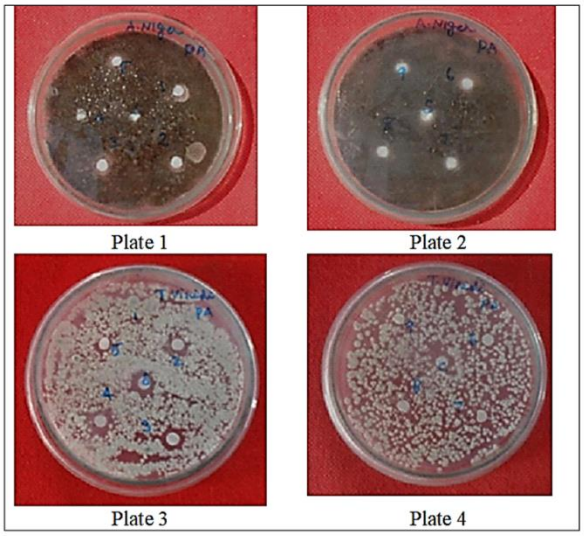



**Figure 3**. Antifungal activity of (*E*)-1,2,3-triphenylprop-2-en-1-ones on Petri plates.

**Table 3.** Zone of inhibition(mm) values of antifungal activities of substituted (*E*)-1,2,3-triphenylprop-2-en-1-ones

| Entry | X | Zone of inhibition (mm) | |
|---|---|---|---|
| | | *A. niger* | *T. viride* |
| 1 | H | 8 | - |
| 2 | 2-Br | 8 | 8 |
| 3 | 2-Cl | 9 | 9 |
| 4 | 4-Cl | - | 9 |
| 5 | 2-F | 7 | 7 |
| 6 | 4-$CH_3$ | 8 | 7 |
| 7 | 2-$OCH_3$ | - | - |
| 8 | 4-$OCH_3$ | 8 | 7 |
| 9 | 3-$NO_2$ | 9 | 8 |
| Standard | Miconazole | 14 | 13 |
| Control | DMSO | - | - |

## 4. Conclusions

Authors demonstrated the ultrasonicated aldol condensation for the synthesis of (*E*)-1,2,3-triphenylprop-2-en-1-ones. More than 88% yield was obtained in this condensation. The influence of solvents on then yields were investigated with various solvents in both ultrasonication and conventional heating methods. Overall, the minimum of 37% yield was obtained and hence this condensation was suitable for enone synthesis. The antimicrobial activities of these enones were measured by disc diffusion method. The enones have 4-$CH_3$, 4-$OCH_3$ and 3-$NO_2$ substituted enones showed good antibacterial activities against *B. subtilis*, *E. coli* and *P. aeruginosa* stains. The 2-Cl and 4-Cl substituted enones shows good antifungal activity against *T. viride* fungal stain. Remaining compounds are shown moderate antimicrobial activities. The reason for good, moderate and poor or inactive antimicrobial activities was stated in terms of their electronic effects.

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## Conflict of interest

The authors declare that there is no conflict of interest regarding this research article.

## References

[1]. B. Banerjee, Recent developments on ultrasound assisted catalyst-free organic synthesis, Ultrason. Sonochem. 35 (2017) 1–14.

[2]. M.S. Singh, S. Chowdhury, Recent developments in solvent-free multicomponent reactions: a perfect synergy for eco-compatible organic synthesis, RSC Adv. 2 (2012) 4547.

[3]. S. Hatanaka, H. Mitome, K. Yasui, S. Hayashi, Single-bubble sonochemiluminescence in aqueous luminol solutions, J. Am. Chem. Soc. 124 (2002) 10250–10251.

[4]. K.M. Swamy, K.L. Narayana, V.N. Misra, Bioleaching with ultrasound, Ultrason. Sonochem. 12 (2005) 301–306.

[5]. D. Chen, S.K. Sharma, A. Mudhoo, Handbook on applications of ultrasound: sonochemistry for sustainability, CRC Press, 2011.

[6]. S. Vyas, Y.P. Ting, A Review of the application of ultrasound in bioleaching and insights from sonication in (bio)chemical processes, Resources 7 (2018) 3. Doi:10.3390/resources7010003.

[7]. G. Ter Haar, Therapeutic applications of ultrasound, Prog. Biophys. Mol. Biol. 93 (2007) 111–129.

[8]. K. Ranganathan, D. Kamalakkannan, R. Suresh, S. P. Sakthinathan, R. Arulkumaran, R. Sundararajan, V. Manikandan, G. Thirunarayanan, Synthesis, Hammett spectral correlation and evaluation of antimicrobial activities of some substituted styryl 4′-piperidinophenyl ketones, Indian J. Chem. 58B (2019)1131-1143.

[9]. S. Balaji, V. Manikandan, M. Rajarajan, V. Usha, S. Rajalakshmi, P. Venkatachalam, I. Muthuvel, G. Thirunarayanan, Investigation of catalytic activity of solid acidic $FeCl_3$/Bentonite catalyst on the synthesis of some (*E*)-1-(2,4-Dimethylthiazol-5-yl)-3-phenylprop-2-en-1-ones by solvent-free technique, Mat. Today Proc. 22 (2020) 931-936.

[10]. K. Ranganathan, D. Kamalakkannan, R. Suresh, S.P. Sakthinathan, R. Arulkumaran, R. Sundararajan, V. Manikandan, P. Venkatachalam, S. Rajalakshmi, I. Muthuvel, G. Thirunarayanan, $Cu^{2+}$/Zeolite catalyzed aldol condensation: Greener synthesis of 4′-piperidinophenyl enones, Mat. Today Proc. 22 (2020) 1196-1199.

[11]. D.K. Yadav, M.A. Quraish, Choline chloride. $ZnCl_2$: green effective and reusable ionic liquid for synthesis of 7-amino-2,4-dioxo-5-phenyl-2,3,4,5-

tetrahydro-1H-pyrano[2,3-d]pyrimidine-6-carbonitrile derivatives, J. Mater. Environ. Sci. 5 (2014) 1075-1078.
[12]. S. Bhavani, M.A. Ashfaq, D. Rambabu, M.V. Basaveswara Rao, M. Pal, Ultrasound assisted Mizoroki–Heck reaction catalyzed by Pd/C: Synthesis of 3-vinyl indoles as potential cytotoxic agents, Arabian J. Chem. 12 (2019) 3836-3846.
[13]. N. Basavegowda, K. Mishra, Y.R. Lee, Ultrasonic-assisted green synthesis of palladium nanoparticles and their nanocatalytic application in multicomponent reaction, New J. Chem. 39 (2015) 972-977.
[14]. M.A.P. Martins, C.P. Frizzo, D.N. Moreira, L. Buriol, P. Machado, Solvent-free heterocyclic synthesis, Chem. Rev. 109 (2009) 4140–4182
[15]. S. Puri, B. Kaur, A. Parmar, H. Kumar, Applications of ultrasound in organic synthesis - A green approach, Current Org. Chem. 17 (2013) 1790-1828.
[16]. A.R. Gholap, K. Venkatesan, R. Pasricha, T. Daniel, R.J. Lahoti, K.V. Srinivasan, Copper- and ligand-free Sonogashira reaction catalyzed by Pd(0) Nanoparticles at Ambient Conditions under ultrasound irradiation, J. Org. Chem. 70 (2005) 4869–4872.
[17]. D. Paprocki, A. Madej, D. Koszelewski, A. Brodzka, R. Ostaszewski, Multicomponent Reactions Accelerated by Aqueous Micelles, Front. Chem. 6 (2018) 502. Doi: 10.3389/fchem.2018.00502.
[18]. J.D. Sprich, G.S. Lewandos, Sonochemical removal of adsorbed water and alcohol from magnesium surfaces, Inorg. Chim. Acta 76 (1983) l241-l242.
[19]. O. Repič, S. Vogt, Ultrasound in organic synthesis: cyclopropanation of olefins with zinc-diiodomethane, Tetrahedron Lett. 23 (1982) 2729-2732.
[20]. N.A. Ross, R.A. Bartsch, High-intensity ultrasound-promoted Reformatsky reactions, J. Org. Chem. 68 (2003) 360–366.
[21]. T. Ando, T. Kimura, Ultrasonic organic synthesis involving non-metal solids, Advances in Sonochemistry, ed. T. J. Mason, JAI Press, London, 1991, vol. 2, p. 211.
[22]. H. Zeng, H. Li, H. Shao, One-pot three-component Mannich-type reactions using sulfamic acid catalyst under ultrasound irradiation, Ultrason. Sonochem. 16 (2009) 758–762.
[23]. J. Einhorn, C. Einhorn, J.L. Luche, Ultrasound in organic synthesis 15. Radical cyclisation of o-allyl benzamides via the sono chemically generated radical anions, Tetrahedron Lett. 29 (1988) 2183-2184.
[24]. L. Huang, F. Qin, Z. Huang, Y. Zhuang, J. Ma, H. Xu, W. Shen, Hierarchical ZSM-5 zeolite synthesized by an ultrasound-assisted method as a long-life catalyst for dehydration of glycerol to acrolein, Ind. Eng. Chem. Res. 55 (2016) 7318–7327.
[25]. V. Usha, V. Thangaraj, G. Thirunarayanan, Antimicrobial potent (2E)-3-chloro-4-nitrophenyl chalcones, Indian J. Chem. 56B (2017) 1094-1102.
[26]. A.W. Bauer, W.M.M. Kirby, J.C. Sherris, M. Truck, Antibiotic susceptibility testing by a standardized single disk method, Am. J. Clin. Pathol. 45 (1996) 493-498.
[27]. R. Suresh, S.P. Sakthinathan, D. Kamalakkannan, I. Muthuvel, G. Thirunarayanan, Synthesis and pharmacological evaluation of some benzylidene-4-nitroanilines, Ovidus Univ. Annal. Chem. 31 (2020) 55-59.
[28]. C. Wang, T. Morimoto, H. Kanashiro, H. Tanimoto, Y. Nishiyama, K. Kakiuchi, L. Artok, Rhodium(I)-catalyzed carbonylative arylation of alkynes with arylboronic acids usisng formaldehyde as a carbonyl source, Synlett 25 (2014) 1155-1159.

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