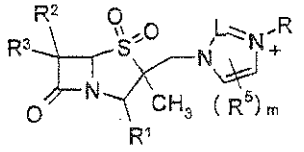
alkylthio (C_1-C_4alkylthio such as methylthio and ethylthio); lower alkylamino (C_1-C_4alkylamino such as methylamino, ethylamino and propylamino); cyclo(lower)alkyl (C_5-C_6cycloalkyl such as cyclopentyl and cyclohexyl); cyclo(lower)alkenyl (C_5-C_6cycloalkenyl such as cyclohexenyl and cyclohexadienyl); hydroxy; halogen (chloro, bromo, fluoro and iodo); amino; protected amino; cyano; nitro; carbamoyl; -CONH C_1-C_4alkyl-COO-C_1-C_4alkyl; carboxy; protected carboxy; -COO-C_1-C_4alkyl; -CO-heterocyclyl; sulfonyl; sulfamoyl; imino; oxo; amino(lower)alkyl such as aminomethyl, aminoethyl and aminopropyl; halo(lower)alkyl such as trifluoromethyl (-CF_3), fluoromethyl, fluoroethyl, bromomethyl and difluoromethyl; carboxylic acid and carboxylic acid derivatives such as hydroxamic acid, ester and amide. Preferred substituents are C_1-C_4alkyl, C_1-C_4alkoxy, C_1-C_4alkylthio, C_1-C_4alkylamino, hydroxyl, halogen and trihalomethyl. The substituents are further optionally substituted with C_1-C_4alkoxycarbonylC_1-C_4alkyl, hydroxyC_1-C_4alkyl; C_1-C_4alkyl, C_6-C_{10}aryl, heterocyclyl and esters.

~~In one aspect,~~ pProvided herein are compounds of formula (II), their derivatives, analogs, tautomeric forms, stereoisomers, polymorphs, solvates, metabolites, prodrugs, hydrates, pharmaceutically acceptable salts and esters for use in inhibition of carbapenemases produced by bacteria; potentiating/restoring the activity of antibiotics, comprising administering a therapeutically effective amount of compound of formula (II), to a subject in need thereof;



(II)

wherein

L = C or N;

R, R^1, R^2 and R^3 are as defined earlier.

R^5 represents hydrogen, C_1-C_6alkyl, C_1-C_6alkoxy, C_1-C_6alkylthio, C_1-C_6alkylamino, hydroxyl, halogen and trihalomethyl; and

m is 0, 1 or 2.

~~In another aspect,~~ pProvided herein is a compound for use in treating and / or preventing infections caused by carbapenemase producing bacteria, comprising administering therapeutically effective amount of compound of formula (I), to a subject in need thereof.

~~In yet another aspect, p~~Provided herein is a compound for use in treating and/or preventing infection caused by carbapenemase producing bacteria comprising administering therapeutically effective amount of compound of formula (I), in combination with suitable antibiotics to a subject in need thereof.

~~In yet other aspect, p~~Provided herein is the compound for use, for treating infections caused by β-lactamases expressed by gram negative bacteria.

~~In yet other aspect, p~~Provided herein is the compound for use, wherein bacteria are selected from *Klebsiella pneumoniae* and *E. coli*.

~~In yet ather aspect, p~~Provided herein is the compound for use, wherein the carbapenemases are selected from KPC-2 and KPC-3.

~~In yet another aspect, p~~Provided herein is the method of treatment or prevention of infection caused by carbapenemase producing bacteria comprising administering therapeutically effective amount of compound of formula (I).

Another ~~aspect~~ embodiment herein includes detection of β-lactamases expressed by Enterobacteriaceae and non- Enterobacteriaceae.

Yet another ~~aspect~~ embodiment herein includes use of compound of formula (I) as a diagnostic reagent for the detection of β-lactamases. The said β-lactamases belong to families of KPC-2, KPC-3 and also ESBLs such as SHV18 producing Enterobacteriaceae.

In one embodiment, provided herein is pharmaceutical composition, comprising a compound of formula (I), as an active ingredient to treat or prevent infections caused by carbapenemase producing bacteria.

In another embodiment, provided herein is pharmaceutical composition comprising a compound of formula (I), as an active ingredient to treat or prevent infections caused by carbapenemase producing bacteria along with

a. one or more compounds of formula (I);
b. one or more antibiotics and
c. one or more pharmaceutically acceptable carrier.

In yet another embodiment, the antibiotics are selected from β-lactam antibiotics.

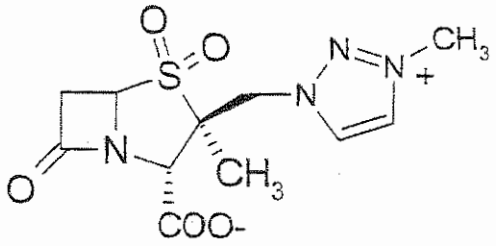
In yet other embodiment, provided herein are the compounds, (2*S*,3*S*,5*R*)-3-Methyl-3-(3-methyl-imidazol-3-ium-1-ylmethyl)-4,4,7-trioxo-4-thia-1-azabicyclo[3.2.0]heptane -2-carboxylate and (2*S*,3*S*,5*R*)-3-Methyl-3-(4-methyl-3-

methyl-imidazol-3-ium-1-ylmethyl)-4,4,7-trioxo-4-thia-1-aza-bicyclo[3.2.0]heptane-2-carboxylate, their derivatives, analogs, tautomeric forms, stereoisomers, polymorphs, solvates, metabolites, prodrugs, pharmaceutically acceptable salts and esters.

In yet another ~~aspect~~ embodiment the compounds (2*S*,3*S*,5*R*)-3-Methyl-3-(3-methyl-imidazol-3-ium-1-ylmethyl)-4,4,7-trioxo-4-thia-1-azabicyclo[3.2.0]heptane-2-carboxylate; (2*S*,3*S*,5*R*)-3-Methyl-3-(4-methyl-3-methyl-imidazol-3-ium-1-ylmethyl)-4,4,7-trioxo-4-thia-1-aza-bicyclo[3.2.0]heptane-2-carboxylate and their derivatives, analogs, tautomeric forms, stereoisomers, polymorphs, solvates, metabolites, prodrugs, pharmaceutically acceptable salts and esters for use in the inhibition of β-lactamases, without limitation, carbapenemases, cephalosporinases, penicillinases, ESBLs and inhibitor-resistant β-lactamases.

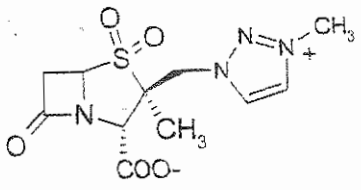
In yet other ~~aspects,~~ embodiments, described herein are the compounds of formula (I) for use in the treatment and/or prevention of bacterial resistance to an antibiotic.

In one aspect, provided herein is the use of a compound of the formula



and its derivatives, analogs, tautomeric forms, stereoisomers, polymorphs, solvates, metabolites, prodrugs, hydrates, pharmaceutically acceptable salts and esters, in the manufacture of a medicament for the treatment or prevention of carbapenemase-producing bacterial infection.

In another aspect, provided herein is the use of a compound of formula



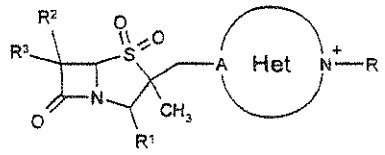
for the manufacture of an *in vitro* diagnostic reagent for the detection of carbapenemases.

Brief Description of Figure:

Figure 1: Double Disk Synergy Test for detection of KPC β-lactamases

Detailed Description

β-Lactam compounds of formula (I),



(I)

their derivatives, analogs, tautomeric forms, stereoisomers, polymorphs, solvates, their pharmaceutically acceptable compositions, pharmaceutically acceptable salts and esters thereof, for use in the inhibition of carbapenemases produced by bacteria; potentiating/restoring the activity of antibiotics, wherein:

Het is a three to seven membered heterocyclic ring which may have suitable substituent(s) and, preferable heterocyclic group such as pyrrolyl, pyrrolinyl, imidazolyl, pyrazolyl, pyridyl, pyrimidinyl, pyrazinyl, piperidinyl, furanyl, thiophenyl, pyrrolidinyl, piperazinyl, oxazolidinyl, thiazolyl, pyridazinyl, tetrazolyl (e.g. 1H-tetrazolyl, 2H-tetrazolyl, *etc.*), imidazolidinyl, triazolyl, 1,2,4-oxadiazolyl, 1,3,4-oxadiazolyl, 1,2,5-oxadiazolyl, 1,2,3-thiadiazolyl, 1,2,4-thiadiazolyl, 1,3,4-thiadiazolyl and 1,2,5-thiadiazolyl.