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— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)*

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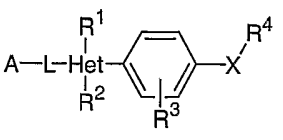
(54) Title: CYCLOALKYL HETEROCYCLES FOR TREATING HEPATITIS C VIRUS



(I)

(57) Abstract: Compounds of Formula (I) are disclosed which inhibit hepatitis C NS5B RNA-dependent RNA polymerase and are useful for treating hepatitis C. Compositions and methods of using these compounds are also disclosed.

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CYCLOALKYL HETEROCYCLES FOR TREATING HEPATITIS C VIRUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. provisional application No. 60/502,067 filed September 11, 2003.

BACKGROUND OF THE INVENTION

This invention is directed to compounds which inhibit the RNA-dependent RNA polymerase (RdRp) encoded by Hepatitis C virus (HCV). The compounds, or pharmaceutically acceptable salts thereof, are useful for the treatment of HCV viral infections.

HCV is a major human pathogen, infecting an estimated 170 million people worldwide. A substantial fraction of these HCV infected individuals develop serious progressive liver disease, including cirrhosis and hepatocellular carcinoma. (Lauer, G. M.; Walker, B. D. *N. Engl. J. Med.* (2001), 345, 41-52).

Presently, the most effective HCV therapy employs a combination of alpha-interferon and ribavirin, leading to sustained efficacy in 40% of patients. (Poynard, T. et al. *Lancet* (1998), 352, 1426-1432). Recent clinical results demonstrate that pegylated alpha-interferon is superior to unmodified alpha-interferon as monotherapy (Zeuzem, S. et al. *N. Engl. J. Med.* (2000), 343, 1666-1672). However, even with experimental therapeutic regimens involving combinations of pegylated alpha-interferon and ribavirin, a substantial fraction of patients do not have a sustained reduction in viral load. In addition, the prospects for development of a prophylactic or therapeutic vaccine appear dim, in spite of intensive research efforts. Thus, there is a clear need to develop effective therapeutics for treatment of HCV infection.

HCV is a positive-stranded RNA virus. Based on comparison of deduced amino acid sequence and the extensive similarity in the 5' untranslated region, HCV has been classified as a separate genus in the Flaviviridae family. All members of the Flaviviridae family have enveloped virions that contain a positive stranded RNA

genome encoding all known virus-specific proteins via translation of a single, uninterrupted, open reading frame.

Considerable heterogeneity is found within the nucleotide and encoded amino acid sequence throughout the HCV genome. At least six major genotypes have been characterized, and more than 50 subtypes have been described. The major genotypes of HCV differ in their distribution worldwide, and the clinical significance of the genetic heterogeneity of HCV remains elusive despite numerous studies of the possible effect of genotypes on pathogenesis and therapy.

The RNA genome is about 9.6 Kb in length, and encodes a single polypeptide of about 3000 amino acids. The 5' untranslated region contains an internal ribosome entry site (IRES), which directs cellular ribosomes to the correct AUG for initiation of translation. The translated product contains the following proteins: core-E1-E2-p7-NS2-NS3-NS4A-NS4B-NS5A-NS5B. This precursor protein is cotranslationally and posttranslationally processed into at least 10 viral structural (core, E1, E2) and nonstructural (NS2-NS5B) proteins by the action of host cell signal peptidase and by two distinct viral proteinase activities (NS2/3 and NS3).

Although the functions of the NS proteins are not completely defined, it is known that NS3 is a serine protease/RNA helicase, NS4A is a protease cofactor, and NS5B is an RNA dependent RNA polymerase involved in viral replication. It has recently been demonstrated that functional NS5B is required for virus infectivity in chimpanzees (Kolykhalov, A. A. et al. *J. Virol.* (2000), 74, 2046-2051). Because HCV only infects chimpanzees and humans, this result strongly suggests that inhibition of the NS5B RdRp is a viable approach for the development of HCV therapeutic agents.

DESCRIPTION OF RELATED ART

Efforts toward the development of HCV NS5B RdRp inhibitors have resulted in the following disclosures:

Altamura et al. (Istituto Di Ricerche Di Biologia Molecolare) describe diketoacid RdRp inhibitors (WO 00/06529). Altamura et al. suggest that the diketoacids inhibit HCV RdRp by interfering with the binding of phosphoryl groups at the active site of the enzyme.

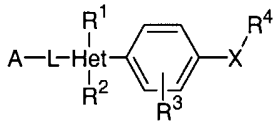
A series of three disclosures from Viropharma Inc. (Bailey, T. R. et al, WO 00/10573; Bailey , T. R. et al, WO 00/13708; Young, D. C. et al, WO 00/18231) describe HCV RdRp inhibitors. WO 00/10573 covers a series of rhodanine derivatives, WO 00/13708 covers a series of barbituric acid or thiobarbituric acid derivatives, and WO 0018231 covers a series of dihydrobenzothiophene derivatives.

R. Storer (Biochem Pharma, Inc.) has disclosed the use of a series of dioxolane nucleosides for treatment of HCV (WO 01/32153). Hashimoto et al, (Japan Tobacco, Inc.) disclose a series of fused-ring heterocycles as inhibitors of HCV RdRp (WO 01/47883, US 03/0050320), and a similar series of fused-ring heterocycles is also disclosed by Boehringer Ingelheim (WO 02/04425, WO 03/007945, WO 03/010141). ShireBiochem (WO 02/100851) discloses 5-membered carboxylates. Agouron Pharmaceuticals discloses pyran-2-ones (EP 1 256 628).

DESCRIPTION OF THE INVENTION

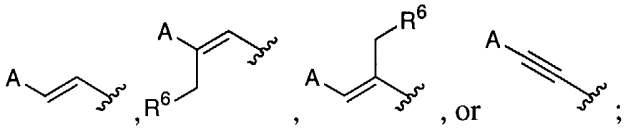
This invention encompasses compounds which are useful for inhibiting hepatitis C NS5B RNA-dependent RNA polymerase and for treating hepatitis C. Pharmaceutical compositions and methods of treating hepatitis C using these compounds are also encompassed.

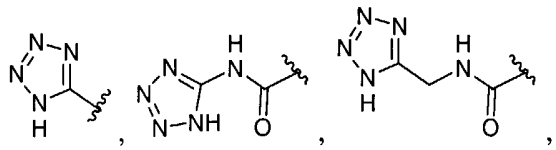
One aspect of the invention are compounds of Formula (I)



I

where:

A-L is $A(CH_2)_{0-6}$–,  ;

A is CO_2R^5, $CONSO_2R^5$, SO_2NCOR^5,  ;

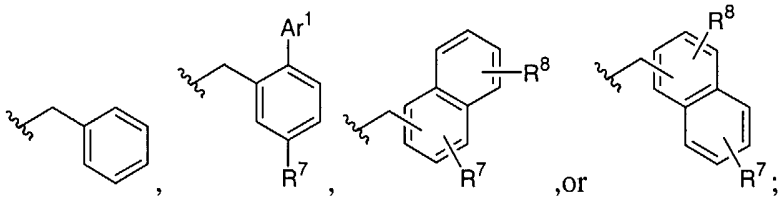
Het is pyrazole, imidazole, oxazole, triazole, thiazole, pyrrole, furan, or thiophene;

X is O, S, NR^5, or CH_2;

R^1 is hydrogen, halogen, C_{1-6}alkyl, trifluoromethyl, or phenyl;

R^2 is C_{3-7}cycloalkyl or C_{5-12} bridged bicycloalkyl;

R^3 is hydrogen, halogen, C_{1-6}alkyl, or C_{1-6}alkoxy;

R^4 is  ;

R^5 is hydrogen or C_{1-6}alkyl;

R^6 is hydrogen, methyl, or OR^5;

R^7 is C_{1-6}alkoxy, cyano, trifluoromethyl, $-CO_2R^5$, $-CONR^9R^{10}$, SO_2R^5, or $SO_2NR^9R^{10}$;

R^8 is hydrogen, halogen, C_{1-6}alkyl, C_{1-6}alkoxy, cyano, trifluoromethyl, aceto, CO_2R^5, or $CONR^9R^{10}$;

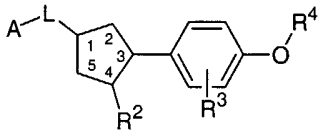
R^9 and R^{10} are independently hydrogen, C_{1-6}alkyl, $-CH_2CH_2OH$; or

NR^9R^{10} taken together form pyrrolidine, piperidine, 4-hydroxypiperidine, piperazine, 4-methylpiperazine, morpholine, or thiomorpholine; and

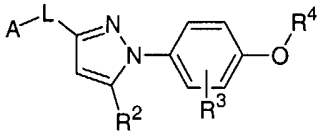
Ar^1 is thiophene or phenyl substituted with 0-3 substituents selected from halogen, C_{1-6}alkyl, C_{1-6}alkoxy, cyano, trifluoromethyl, aceto, CO_2R^5, and $CONR^9R^{10}$;

and pharmaceutically acceptable salts and solvates of these compounds.

Another aspect of the invention are compounds which have the following 1,3,4 geometric configuration on a 5-member heterocyclic ring:

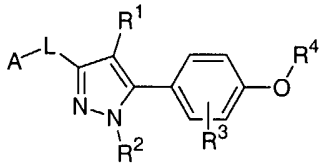


Another aspect of this invention are compounds of Formula Ia.



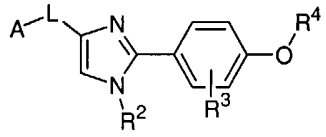
Ia

Another aspect of this invention are compounds of Formula Ib.



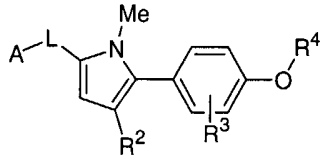
Ib

Another aspect of this invention are compounds of Formula Ic.



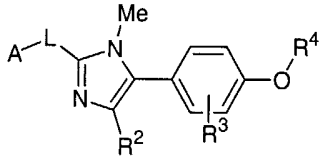
Ic

Another aspect of this invention are compounds of Formula Id.



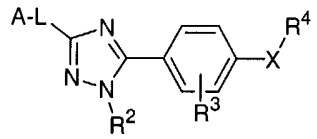
Id

Another aspect of this invention are compounds of Formula Ie.



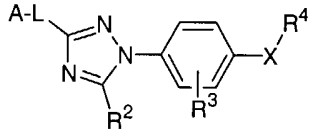
Ie

Another aspect of this invention are compounds of Formula If.



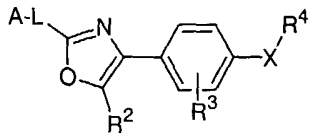
If

Another aspect of this invention are compounds of Formula Ig.



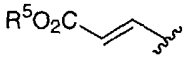
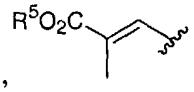
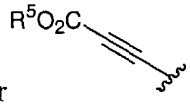
Ig

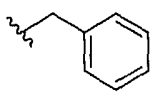
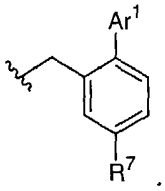
Another aspect of this invention are compounds of Formula Ih.



Ih

Another aspect of the invention are compounds of Formula I where A is $-CO_2R^5$.

Another aspect of the invention are compounds of Formula I where A-L is $-CO_2R^5$, $-(CH_2)_{1-6}CO_2R^5$,  ,  , or  .

Another aspect of the invention are compounds of Formula I where R^4 is  or  . For this aspect, we note that a very broad range of substituents at Ar^1, including hydrogen and heteroaryl moieties, have relatively minor effect on the activity of the compounds. In contrast, activity of the compounds are enhanced when R^7 is a polar moiety.

Some bridged bicycloalkyl groups include bicyclo[1.1.1]pentane, bicyclo[2.1.1]hexane, bicyclo[2.2.1]heptane, bicyclo[2.2.2]octane, bicyclo[3.1.1]heptane, bicyclo[3.2.1]octane, bicyclo[3.3.1]nonane, bicyclo[3.3.3]undecane, and adamantane.

Some compounds of the invention include the following:

(1) ethyl 1-cyclohexyl-5-(4-benzyloxyphenyl)-1*H*-pyrazole-3-carboxylate;

(2) methyl (2*E*)-3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-propenoate;

(3) (2*E*)-3-[1-cyclohexyl-5-(4-benzyloxyphenyl)-1*H*-pyrazol-3-yl]-2-propenoic acid;

(4) methyl (2E)-3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-pyrazol-3-yl)-2-propenoate;

(5) (2*E*)-3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-propenoic acid;

(6) ethyl (2*E*)-3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-methyl-2-propenoate;

(7) (2*E*)-3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-methyl-2-propenoic acid;

(8) ethyl (2*E*)-3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoate;

(9) (2*E*)-3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoic acid;

(10) ethyl (2*E*)-3-(5-{4-[(*t*-butyl-2-bromo-5-phenylcarboxylate)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoate;

(11) ethyl (2*E*)-3-(5-{4-[(4'-chloro-4-t-butoxycarbonyl-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoate;

(12) ethyl (2*E*)-3-(5-{4-[(4'-Chloro-4-N-methylcarbamoyl-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoate;

(13) (2*E*)-3-(5-{4-[(4'-Chloro-4-N-methylcarbamoyl-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoic acid;

(14) methyl 3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}propanoate;

(15) 3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}propanoic acid;

(16) methyl 3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)propanoate;

(17) 3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)propanoic acid;

(18) ethyl 3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-propynoate;

(19) 3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-propynoic acid;

(20) ethyl 3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-propynoate;

(21) 3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-propynoic acid;

(22) ethyl 5-[4-(benzyloxy)phenyl]-4-bromo-1-cyclohexyl-1*H*-pyrazole-3-carboxylate;

(23) methyl (2*E*)-3-{5-[4-(benzyloxy)phenyl]-4-bromo-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-propenoate;

(24) (2*E*)-3-{5-[4-(benzyloxy)phenyl]-4-bromo-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-propenoic acid;

(25) methyl (2*E*)-3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-4-phenyl-1*H*-pyrazol-3-yl}-2-propenate;

(26) (2*E*)-3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-4-phenyl-1*H*-pyrazol-3-yl}-2-propenoic acid;

(27) methyl (2*E*)-3-(5-{4-[4'-chloro-4-methoxy-1,1-biphenyl)methoxy]phenyl}-1-cyclohexyl-4-phenyl-5-1*H*-pyrazol-3-yl]-2-propenoate;

(28) (2*E*)-3-(5-{4-[4'-chloro-4-methoxy-1,1-biphenyl)methoxy]phenyl}-1-cyclohexyl-4-phenyl-5-1*H*-pyrazol-3-yl]-2-propenoic acid;

(29) ethyl 1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazole-3-carboxylate;

(30) methyl (2*E*)-3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}-2-propenoate;

(31) (2*E*)-3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}-2-propenoic acid;

(32) methyl (2*E*)-3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)-2-propenoate;

(33) (2*E*)-3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)-2-propenoic acid;

(34) ethyl (2*E*)-3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}-2-methyl-2-propenoate;

(35) (2*E*)-3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}-2-methyl-2-propenoic acid;

(36) ethyl (2*E*)-3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoate;

(37) (2*E*)-3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoic acid;

(38) ethyl (2E)-1-[4-(4'-Chloro-4-methylcarbamoyl-biphenyl-2-ylmethoxy)-phenyl]-5-cyclohexyl-1H-pyrazol-3-yl]-2-methyl-2-propenoate;

(39) (2E)-1-[4-(4'-chloro-4-methylcarbamoyl-biphenyl-2-ylmethoxy)-phenyl]-5-cyclohexyl-1H-pyrazol-3-yl]-2-methyl-2-propenoic acid;

(40) methyl 3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}propanoate;

(41) 3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}propenoic acid;

(42) methyl 3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)propanoate;

(43) 3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)propanoic acid;

(44) *tert*-butyl (2*E*)-3-{2-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-imidazol-4-yl}-2-propenoate;

(45) (2*E*)-3-{2-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-imidazol-4-yl}-2-propenoic acid;

(46) methyl (2*E*)-3-{2-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-imidazol-4-yl}-2-propenoate;

(47) methyl (2E)-3-(2-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-propenoate;

(48) (2E)-3-(2-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-propenoic acid;

(49) ethyl (2*E*)-3-{2-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-imidazol-4-yl}-2-methyl-2-propenoate;

(50) (2E)-3-{2-[4-(benzyloxy)phenyl]-1-cyclohexyl-1H-imidazol-4-yl}-2-methyl-2-propenoic acid;

(51) ethyl (2E)-3-(2-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-methyl-2-propenoate;

(52) (2E)-3-(2-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-methyl-2-propenoic acid;

(53) t-Butoxy (2E)-3-(2-{4-[(4'-chloro-4-N-methylcarbamoyl-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-methyl-2-propenoate; and

(54) (2E)-3-(2-{4-[(4'-chloro-4-N-methylcarbamoyl-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-methyl-2-propenoic acid.

"Aryl" includes both carbocyclic and heterocyclic aromatic ring systems. "Het" means a heteroaryl ring. "Alkyl" and "alkoxy" include straight and branched confugurations. The term "halogen" includes fluorine, chlorine, bromine, and iodine.

The invention includes all pharmaceutically acceptable salt forms of the instant compounds. Pharmaceutically acceptable salts are those in which the counter

ions do not contribute significantly to the physiological activity or toxicity of the compounds and as such function as pharmacological equivalents. In many instances, salts have physical properties that make them desirable, such as solubility or crystallinity. The salts can be made according to common organic techniques employing commercially available reagents. Suitable anionic salt forms include acetate, acistrate, besylate, bromide, chloride, citrate, fumarate, glucouronate, hydrobromide, hydrochloride, hydroiodide, iodide, lactate, maleate, mesylate, nitrate, pamoate, phosphate, succinate, sulfate, tartrate, tosylate, and xinofoate. Suitable cationic salt forms include ammonium, aluminum, benzathine, bismuth, calcium, choline, diethylamine, diethanolamine, lithium, magnesium, meglumine, 4-phenylcyclohexylamine, piperazine, potassium, sodium, tromethamine, and zinc.

The invention also includes all solvated forms of the instant compounds. Solvate forms do not contribute significantly to the physiological activity or toxicity of the compounds and as such function as pharmacological equivalents. Solvates may form in stoichiometric amounts or may form with adventitious solvent or a combination of both. One type of solvate is hydrate and some hydrated forms include monohydrate, hemihydrate, and dihydrate, but other forms can be encountered.

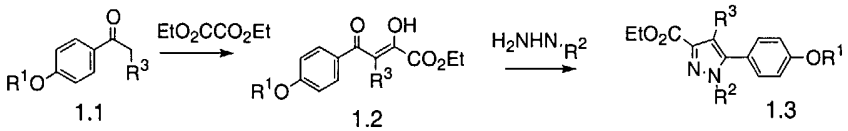
Synthesis

The novel compounds of this invention can be prepared using reactions and techniques described in this section or known in the art. The starting materials are commercially available or can be prepared by methods known in the art. Reactions are performed in solvents appropriate to the reagents and materials employed.

Synthetic routes to carboxylate acids and esters depicted below can be adapted by methods known to one skilled in the art to allow for the preparation of nitriles, halogens, or sulphonate esters, or other functional groups that may be converted to carboxylate isosteres by various methods. These substituents may be interconverted as necessary by a wide variety of methods known to one skilled in the art of organic synthesis.

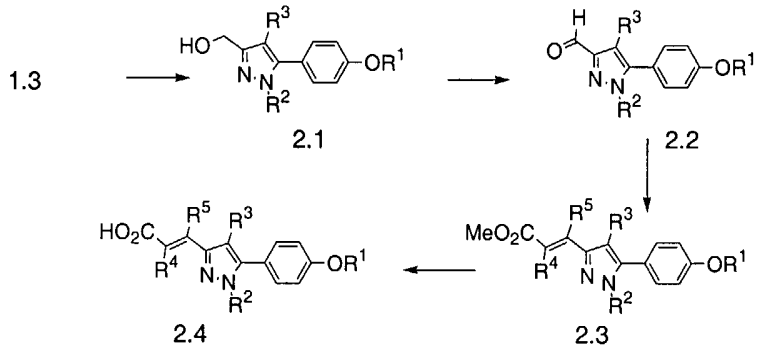
Scheme 1 describes the synthesis of 1-cycloalkylpyrazoles and begins with the conversion of protected 4-hydroxyphenyl methyl ketones (**1.1**) to diketoesters **1.2**. This intermediate can be condensed with a cycloalkyl-substituted hydrazines to afford pyrazoles **1.3**. Thus, substituents R^1 and R^2 and R^3 can be varied by the choice of starting materials, and if R^3 is initially H, then it can be replaced by bromine via a bromination reaction, and further modified via Pd^0 coupling or metal-halogen exchange followed by reaction with an appropriate electrophile.

Scheme 1



Scheme 2 depicts elaboration to α,β-unsaturated carboxylates beginning from esters **1.3** of Scheme 1. Reduction to alcohols **2.1** followed by oxidation can give aldehydes **2.2** which can then be coupled with an appropriate Wittig or equivalent reagent to provide the α,β-unsaturated esters **2.3**. Saponification of **2.3** can provide carboxylic acids **2.4.** It is envisioned that aldehydes **2.2** can be coupled with olefination reagents to provide α,β -unsaturated sulfonate esters, nitriles, or other intermediates that can be converted to carboxylate isosteres.

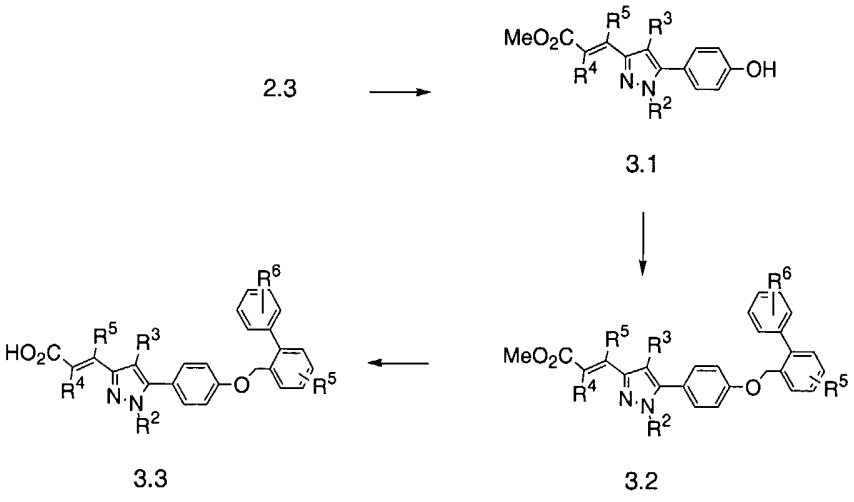
Scheme 2



Preparation of biphenyl sidechain analogs as drawn in Scheme 3 requires removal of R^1 from **2.3** to liberate phenols **3.1**. Alkylation **3.1** can give biphenyl

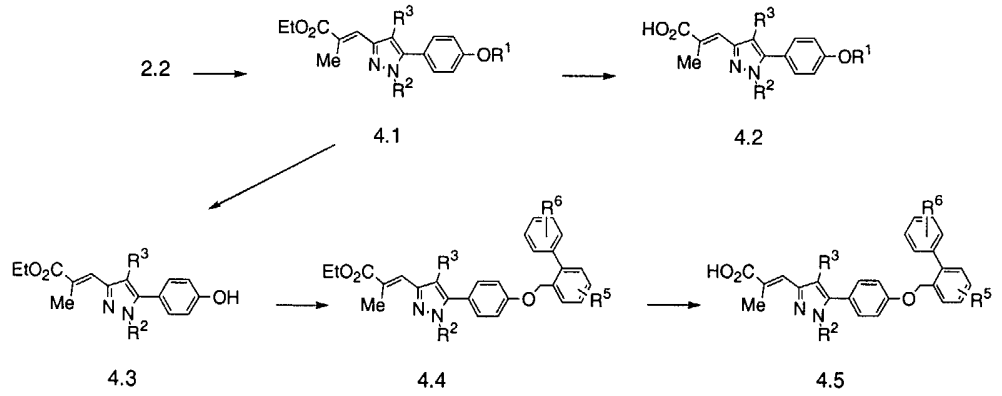
analogs **3.2** which can be hydrolyzed at the methyl ester to provide compounds **3.3**. Substituents R^4 and R^5 can be varied by choice of reagent.

Scheme 3



In Scheme 4, reaction of aldehyde analogs **2.2** with a Wittig like reagent can give methyl substituted analogs of structure **4.1**, and hydroylsis of **4.1** can give carboxylic acids **4.2**. Alternatively, deprotection (removal of R^1 from **4.1**) can give phenols **4.3**, and alkylation of the phenols can provide biphenyl analogs **4.4** which can be further subjected to ester saponification to arrive at carboxylic acids **4.5** possessing HCV inhibitory activity.

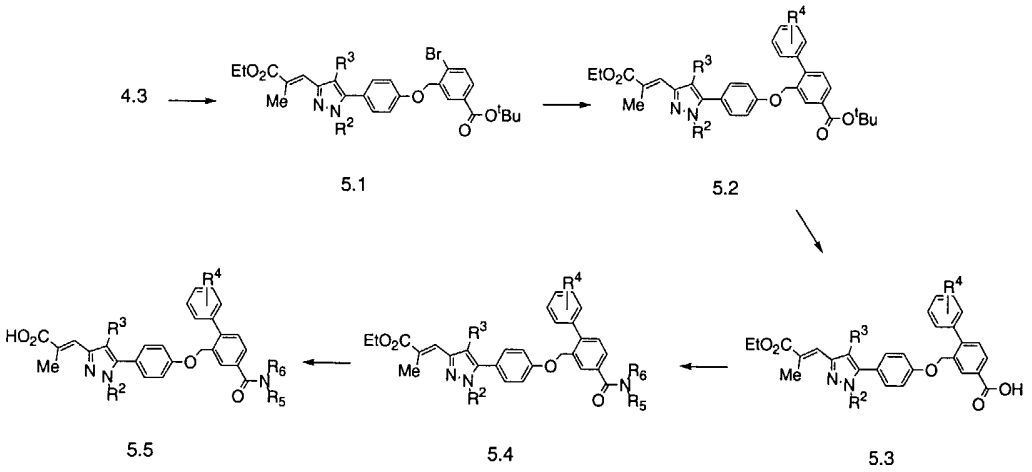
Scheme 4



As outlined in Scheme 5, compounds of structure **4.3** can be alkylated to give bromide analogs **5.1**. Theses analogs can be derivatized via coupling chemistry to

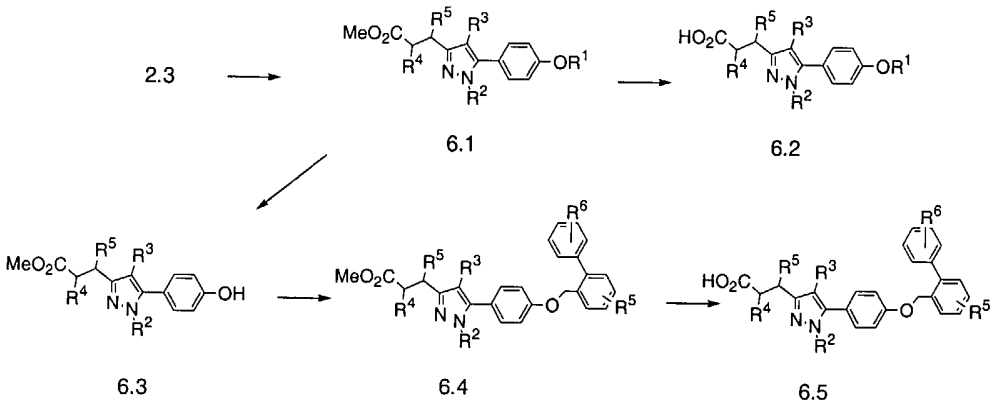
biphenyl structures **5.2**. Cleavage of the *tert*-butyl ester can give carboxylates **5.3** which can be coupled with amines to form amides **5.4.** Saponification of the ethyl ester can give carboxylates **5.5**.

Scheme 5



The olefinic double can be reduced to give saturated compounds of scheme 6. Hydrogenation of methyl esters **2.3** can provide propanoates **6.1**, and propanoic acids **6.2** after saponification. Following the sequence of Scheme 3, phenols **6.3** can be obtained upon deprotection of **6.1**, and alkylation of **6.3** as above can give biphenyl analogs **6.4**. A further step of hyrolysis can give carboxylic acid compounds **6.5**.

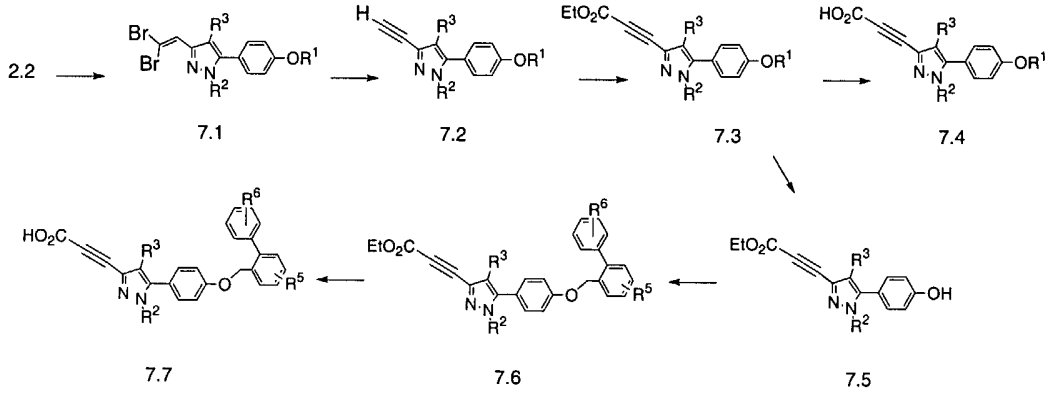
Scheme 6



Scheme 7 depicts the synthetic entry into an alkynyl series of biphenyl analogs. The reaction of carbon tetrabromide and triphenylphosphene on aldehyde

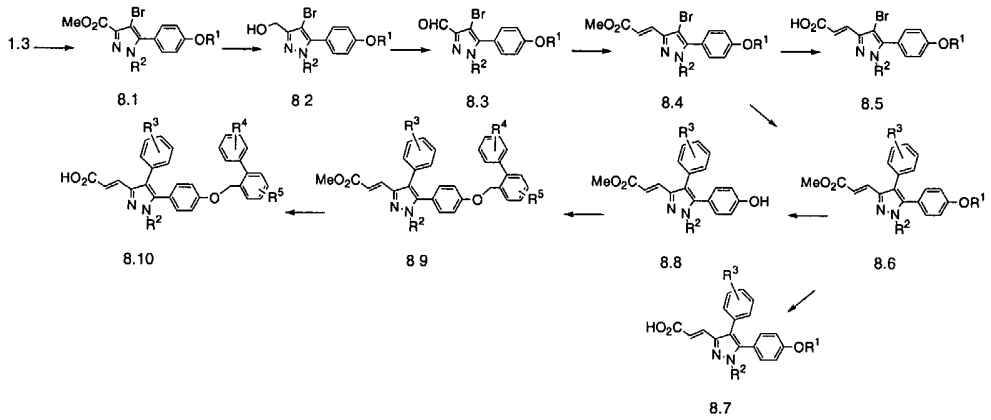
2.2 can give vinyl dibromides **7.1**, which upon subjection to butyl lithium can afford acetylenes **7.2**. Deprotonation and quench with chloroformate can provide ethyl esters **7.3** which can be hydrolyzed to **7.4**. Alternatively, deprotection of **7.3** yields phenols **7.5** which can be further subjected to alkylation, and the resulting biphenyl analogs **7.6** can be saponified to carboxylic acid compounds **7.7**.

Scheme 7



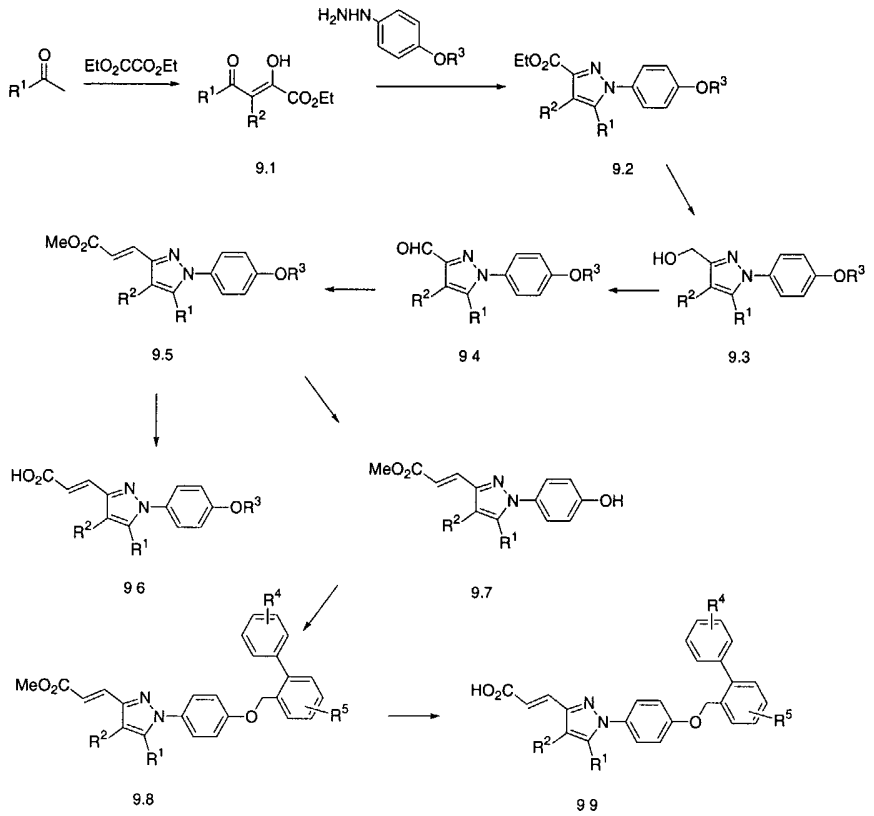
Scheme 8 outlines bromination of pyrazoles **1.3** to give bromides **8.1** which can be used to obtain pyrazoles substituted at the 4-postion. Thus, **8.1** can be reduced to alcohols **8.2**, oxidized to aldehydes **8.3**, treated with Wittig reagent to afford propenoates **8.4**, and saponified to **8.5** according to methods above. Bromides **8.4** can be coupled with phenyl boronic acids to give rise to 4-phenyl analogs **8.6,** saponification of which leads to acids **8.7**, or removal of R^1 can give phenols **8.8.** As above, alkylation of the phenol can give biphenyls **8.9**, and saponification can provide carboxylates **8.10**.

Scheme 8



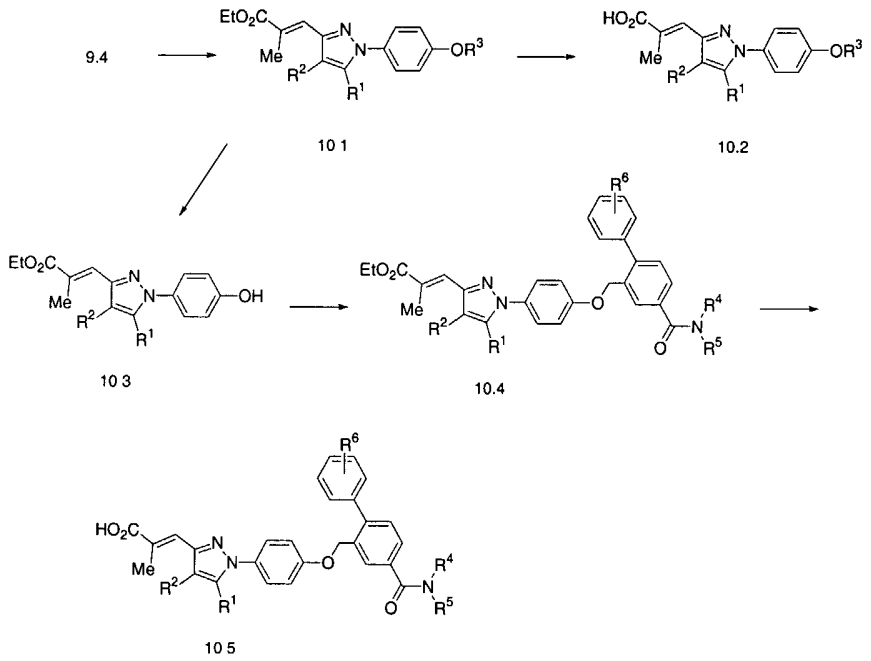
Scheme 9 depicts preparation of another type of compound, 5-cycloalkylpyrazole derivatives. Diketoesters **9.1** can be obtained upon treatment of cycloalkyl methyl ketones with ethyl oxalate, and can be subsequently condensed with substituted phenylhydrazines to give 5-cycloalkylpyrazoles **9.2.** Substituents R^1, R^2, and R^3 can be varied by the choice of starting materials. If substituent R^2 is H, then bromine can be introduced via bromination with Br_2 in acetic acid, followed by further modification of the bromo substituent via Pd^o coupling or other derivation known to those skilled in the art. As above, reduction of **9.2** to alcohols **9.3**, oxidation of **9.3** to aldehydes **9.4**, and Wittig reaction to **9.5** can give compounds suitable for further elaboration to biphenyl derivatives. While saponification of esters **9.5** can give acids **9.6**, deprotection of **9.5** (removal of R^3) can provide **9.7** which can be alkylated to biphenyls **9.8**, and further saponification can yield carboxylates **9.9**.

Scheme 9



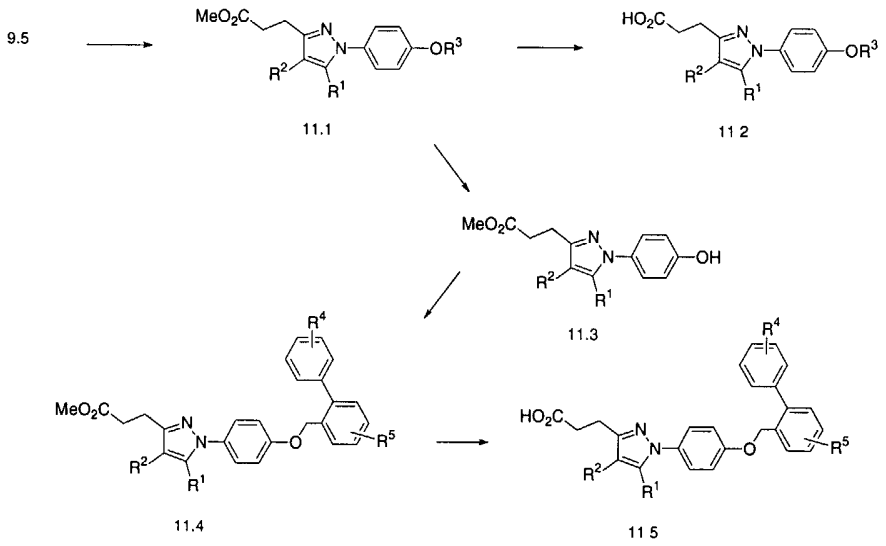
In a simlar sequence to Schemes 4 and 5, aldehydes **9.4** can be carried forward (Scheme 10) to give biphenylamides. Thus, exposure to Wittig conditions can afford 2-methylpropenaotes **10.1** which can be saponified to acids **10.2**. Alternatively, **10.1** can be deprotected (removal of R^3) to generate phenols **10.3** which can be alkylated to give biphenyl amides **10.4**, and further saponification provides carboxylic acids **10.5.**

Scheme 10



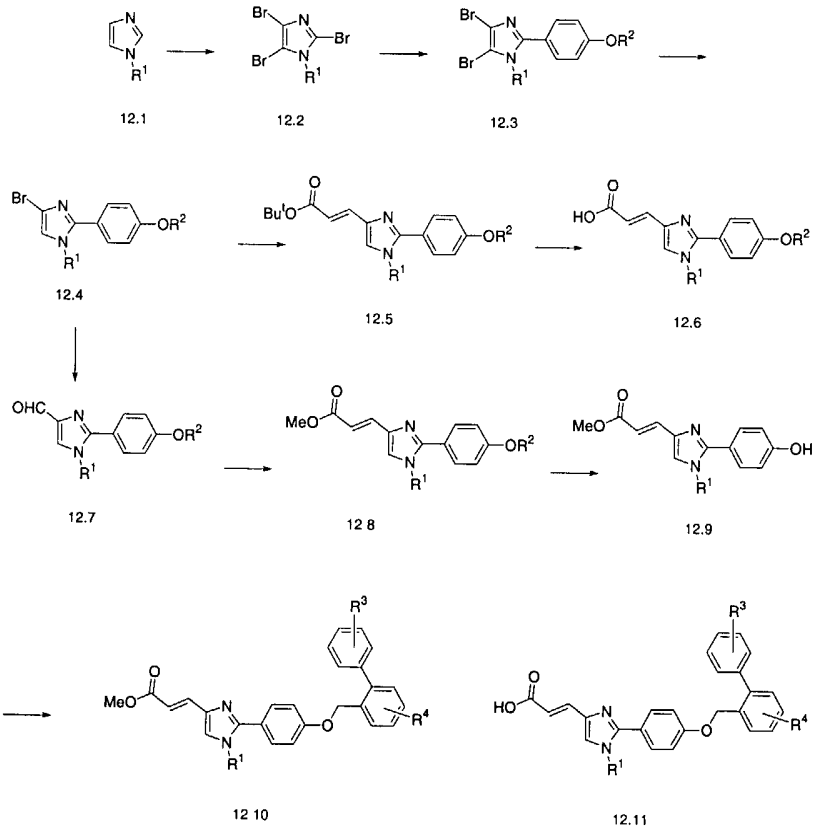
In similar manner to Scheme 6, propenoates **9.5** can be reduced to give saturated compounds **11.1** shown in Scheme 11. Saponification can provide carboxylic acids **11.2**, and removal of R^3 gives phenols **11.3**. Alkylation to biphenyl derivatives **11.4** and hydrolysis of **11.4** provides propanoic acids analogs **11.5**.

Scheme 11



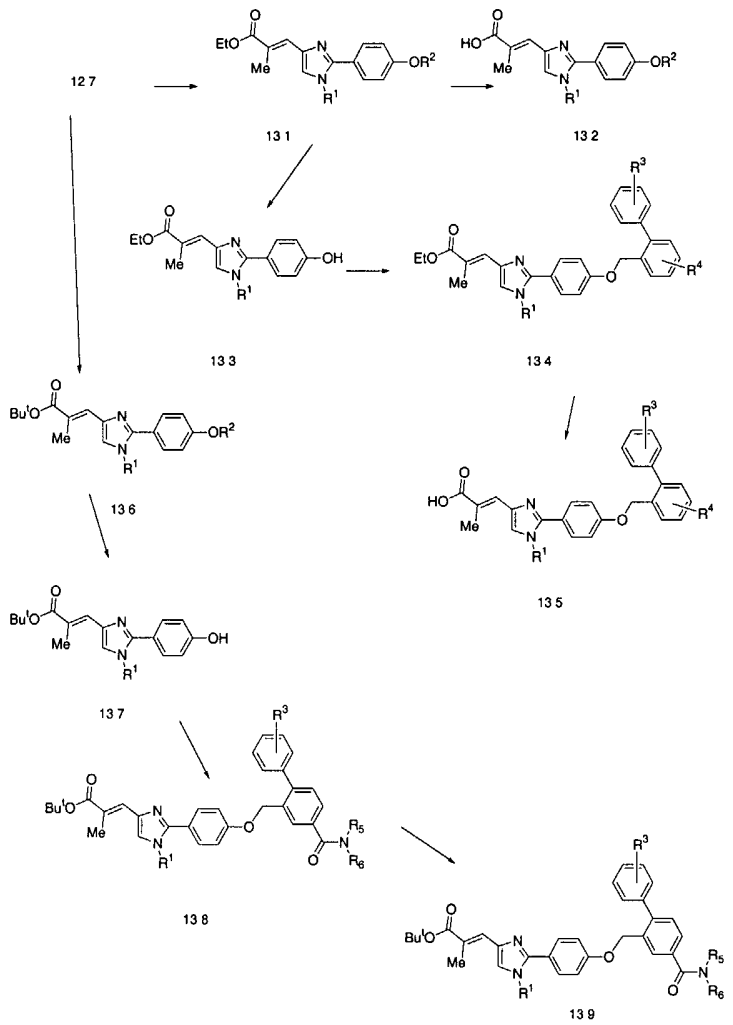
Cycloalkylimidazole derivatives are depicted in scheme 12. Cycloalkylimdazoles **12.1** can be brominated to tribromide **12.2.** Coupling at the 2-position can give **12.3** which can be selectively debrominated to **12.4**, and coupled at the 4-position to give **12.5** which can be saponified to generate carboxylates **12.6**. Alternatively, transmetalation of **12.4** and quench with DMF can give aldehydes **12.7**. Wittig olefination of **12.7** can afford α,β-unsaturated esters **12.8** which can be deprotected (removal of R^2) to yield phenols **12.9**. Alkylation of **12.9** and saponification of the resulting biphenyl analogs can give **12.10** and **12.11**, respectively.

Scheme 12



As depicted above in schemes 4 and 10, a similar sequence is defined in scheme 13 for 2-methyl substitution on the propenoate sidechain. Thus, aldehydes **12.7** can be treated with Wittig-like reagents to provide derivatives **13.1**, which can be saponified to **13.2**, or deprotected to phenols **13.3**. Alklation of phenols can give biphenyls **13.4**, and saponification can give carboxylates **13.5**.

Scheme 13

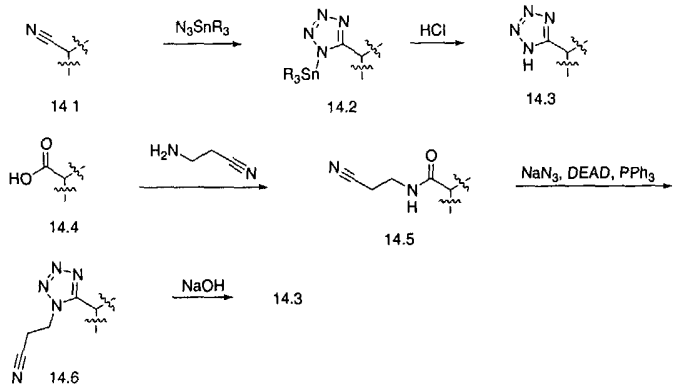


Carboxylate isostere groups can be incorporated into the compounds of this invention. The heterocycles prepared in schemes 1-13 each bear a carboxylic acid liberated through hydrolysis in the final step of the synthesis. The carboxylic acid can be replaced with an equivalent group or isostere introduced in the final step of synthesis, or during synthesis of precursors to the final compound. In schemes 14-19, only the carboxylate isostere and its attached carbon atom are explicitly shown, however, they can be incorporated into the heterocycles of this invention by methods known in the art of synthetic organic chemistry.

Scheme 14 illustrates the synthesis of tetrazole derivatives. For a leading reference, see: Duncia, J. V., et al. *J. Org. Chem.* (1991), 56, 2395-2400; Herr, J. R.

Bioorg. & Med. Chem. (2002), 10, 3379-3393. Nitrile **14.1** can be reacted with a trialkyltin azide, optionally prepared *in situ* from a trialykltin chloride and metal azide, in a solvent such as toluene at elevated temperature to afford tetrazole **14.2**. The trialkyltin moiety can be removed by treatment with hydrogen chloride to afford the deprotected tetrazole **14.3**. As an alternative, nitrile **14.1** can be converted directly to tetrazole **14.3** by treatment with sodium azide and ammonium chloride (or trialkylammonium hydrochloride, in an aromatic solvent: Koguro, K. et al. *Synthesis* (1998), 910-914) in a solvent such as DMF at elevated temperature. Another approach, where R1 is a carboxylic acid, the acid **14.4** can be coupled to 3-aminopropionitrile using DCC in dichloromethane. Treatment of the resulting amide **14.5** with sodium azide under Mitsonobu conditions can afford the tetrazole **14.6**, which may be deprotected by a variety of basic reagents to provide the deprotected tetrazole **14.3**.

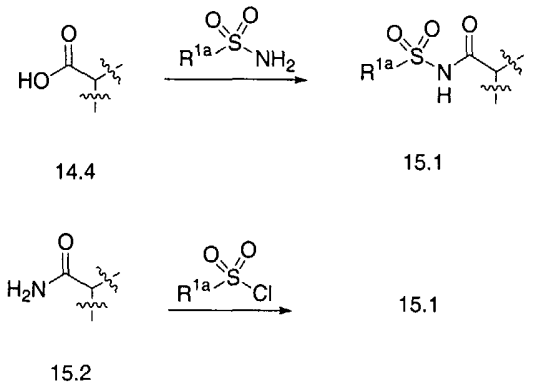
Scheme 14



Scheme 15 depicts the synthesis of acylsulfonamide derivatives from carboxylic acids and primary carboxamides. Carboxylic acid **14.4** can be treated with a sulfonamide and a coupling agent, 1-(3-dimethylaminopropyl-3-ethylcarbodiimide (EDC), and DMAP (Sturino, C. F., et al. *Tetrahedron Lett.* (1998), 39, 5891-5894) to generate acylsulfonamide **15.1**. Other conditions include formation of a carbonylimidazolide by treatment of **14.4** with carbonyl diimidazole (CDI), followed by a sulfonamide and DBU (Drummond, J. T.; Johnson, G. *Tetrahedron Lett.* (1988), 27, 1653-1656), or formation of an acid chloride by treatment of **14.4** with thionyl chloride, followed by reaction with the sodium salt of a sulfonamide in

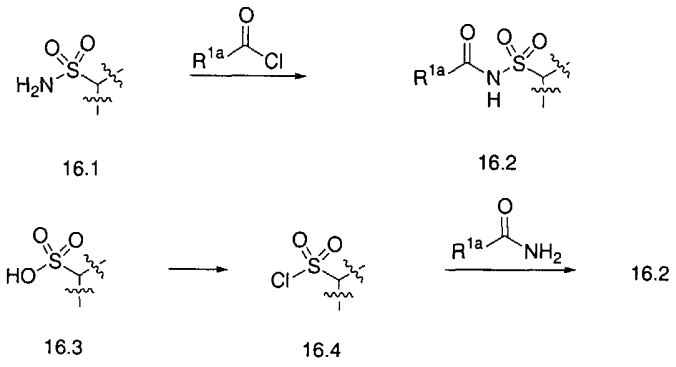
DMF/dichloromethane. Alternatively, compound **15.1** can be prepared by reaction of primary amide **15.2** with an appropriate sulfonyl chloride in a solvent such as pyridine at elevated temperature (Cossu, S.; Giacomelli, G.; Conti, S.; Falorni, M.; *Tetrahedron* (1994), 50, 5083-5090).

Scheme 15



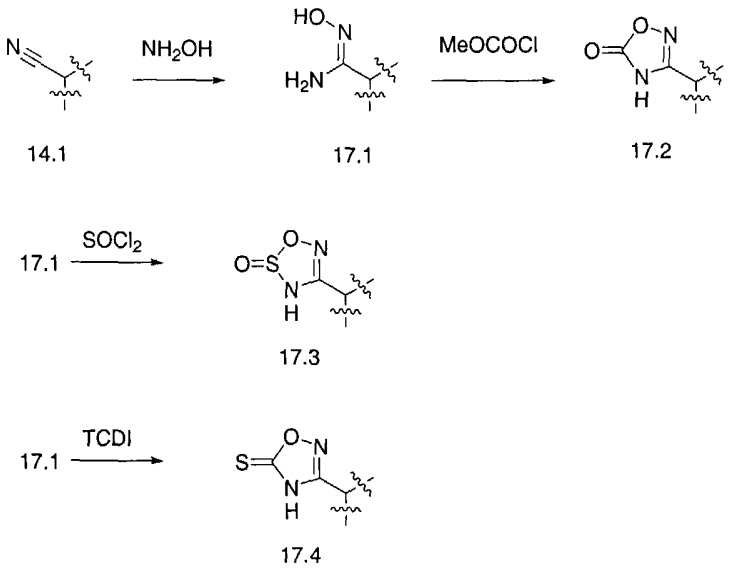
The synthesis of acylsulfonamide compounds from primary sulfonamides or sulfonic acids is shown in scheme 16 where compound **16.1** can be converted to an acylsulfonamide **16.2** upon reaction with an acid chloride and DMAP in pyridine or with an isocyanate (Mantlo, N. B. et al. *Bioorg. Med. Chem. Lett.* (1994), 4, 17-22). Moreover, sulfonic acid **16.3** can be converted to sulfonyl chloride **16.4** by treatment with phosphorous oxychloride, phosphorous pentachloride, or a mixture of the two, or with thionyl chloride, in a solvent such as benzene, toluene, or DMF. Addition of a primary amide to chloride **16.4** is facilitated by DMAP in pyridine at elevated temperature to provide another entry into acylsulfonamides **16.2**.

Scheme 16



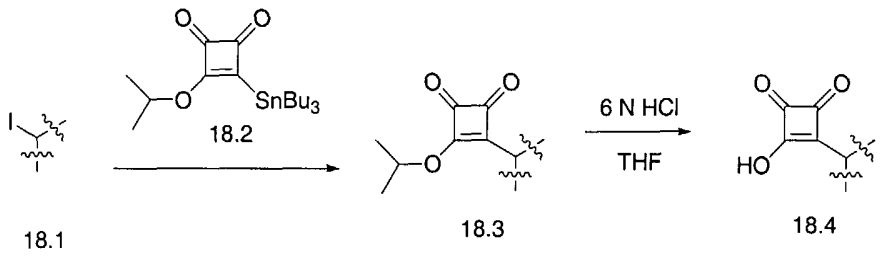
Hydroxylamine can be added to nitrile **14.1** to form amidoxime **17.1** in solvents such as EtOH, DMF, or DMSO at elevated temperature as outlined in scheme 17. Amidoxime **17.1** can be further cyclized to 5-oxo-1,2,4-oxadiazole **17.2** when treated with methylchloroformate and a base reagent such as pyridine, followed by reflux in toluene (Kohara, Y. et al. *Bioorg. Med. Chem. Lett.* (1995), 5, 1903-1908). Alternatively, **17.1** can form oxathiadiazole **17.3** in the presence of $SOCl_2$ in pyridine (Kim, D. et al. *Bioorg. Med. Chem. Lett.* (1994), 4, 41-44). And, in a similar way amidoxime **17.1** can be converted to oxadiazole 17.4 when reacted with thiocarbonyldiimidazole and DBU in acetonitrile (Gezginci, et al. *J. Med. Chem.* (2001), 44, 1560-1563).

Scheme 17



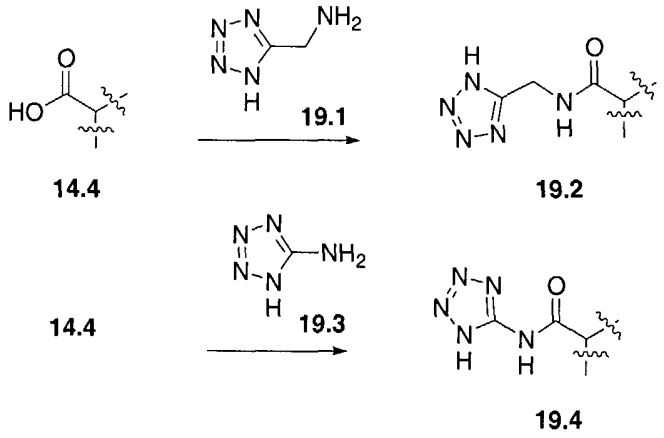
Scheme 18 depicts synthesis of 3-hydroxy-3-cyclobutene-1,2-dione compounds from iodide **18.1** which can be coupled to stannyl cyclobutene **18.2** (Soll, R. M. et al. Bioorg. *Med. Chem. Lett.* (1993), 3, 757-760) using catalytic trans-benzyl(chloro)bis(triphenyl phosphine)palladium(II) and copper(I) iodide in acetonitrile at elevated temperature (Liebskind, L. S.; Fengl, R. W. *J. Org. Chem.* (1990), 55, 5359) to afford compound **18.3**, and acidic hydrolysis can provide 3-hydroxy-3-cyclobutene-1,2-dione **18.4**.

Scheme 18



Carboxylic acid **14.4** can be coupled with 5-aminomethyltetrazole **19.1** (available commercially from Dynamit Nobel GmbH, Leverkusen, Germany) using any of a variety of peptide coupling reagents, including EDC and 1-hydroxybenzotriazole in dichloromethane or DMF, to give 1H-tetraazol-5-ylmethyl carboxamide **19.2**. Under similar reaction conditions, **14.4** can be coupled with 5-aminotetrazole **19.3** to afford 1H-tetraazol-5-yl carboxamide **19.4**.

Scheme 19



Other carboxylate isosteres claimed in the present invention can be synthesized by methods known to one skilled in the art of organic synthesis. For example, preparation of phosphinic and phosphonic acid analogs (Kehler, J. et al. *Bioorg. Med. Chem. Lett.* (2000), 10, 2547-2548), hydroxamic acids (Golebiowski *Tet. Lett.* (1998), 39, 3397), etc.

Biological Activity

Compounds of Formula I inhibit the activity of Hepatitis C Virus NS5B RdRp as demonstrated using assays measuring NS5B RdRp activity.

HCV NS5B RdRp cloning, expression, and purification. The cDNA encoding the NS5B protein of HCV, genotype 1b, was cloned into the pET21a expression vector. The protein was expressed with an 18 amino acid C-terminal truncation to enhance the solubility. The E. coli competent cell line BL21(DE3) was used for expression of the protein. Cultures were grown at 37°C for ~ 4 hours until the cultures reached an optical density of 2.0 at 600 nm. The cultures were cooled to 20°C and induced with 1 mM IPTG. Fresh ampicillin was added to a final concentration of 50 ug/ml and the cells were grown overnight at 20°C.

Cell pellets (3L) were lysed for purification to yield 15-24 mgs of purified NS5B. The lysis buffer consisted of 20 mM Tris-HCl, pH 7.4, 500 mM NaCl, 0.5% triton X-100, 1 mM DTT, 1mM EDTA, 20% glycerol, 0.5 mg/ml lysozyme, 10 mM MgCl2, 15 ug/ml deoxyribonuclease I, and Complete TM protease inhibitor tablets (Roche). After addition of the lysis buffer, frozen cell pellets were resuspended using a tissue homogenizer. To reduce the viscosity of the sample, aliquots of the lysate were sonicated on ice using a microtip attached to a Branson sonicator. The sonicated lysate was centrifuged at 100,000 x g for 1hr at 4°C and filtered through a 0.2 μm filter unit (Corning).

The protein was purified using three sequential chromatography steps: Heparin sepharose CL-6B, polyU sepharose 4B, and Hitrap SP sepharose (Pharmacia). The chromatography buffers were identical to the lysis buffer but contained no lysozyme, deoxyribonuclease I, MgCl2 or protease inhibitor and the NaCl concentration of the buffer was adjusted according to the requirements for charging the protein onto the column. Each column was eluted with a NaCl gradient which varied in length from 5-50 column volumes depending on the column type. After the final chromatography step, the resulting purity of the enzyme is >90% based on SDS-PAGE analysis. The enzyme was aliquoted and stored at –80°C.

HCV NS5B RdRp enzyme assay. HCV RdRp genotype 1b assays were run in assay buffer composed of 20 mM Tris-HCl, pH 7.5, 2.5 mM KCl, 5 mM $MgCl_2$, 1 mM DTT, 1.6 U RNAse inhibitor (Promega N2515), in 96 well plates (Falcon 3918). All compounds were serially diluted in DMSO and diluted further in assay buffer such that the final concentration of DMSO in the assay was 2%. Compounds were serially diluted (3-fold each time) for a 7 point inhibition analysis. HCV RdRp genotype 1b enzyme was used at a final concentration of 28 nM. A polyA template was used at 28 nM, and the oligo-dT_{12-18} primer was used at 840 nM final concentration. Preannealed primer and template were obtained commercially (Amersham 27-787802). ^{3}H-UTP was used at 0.125 μCi (1 μM total UTP). Reaction was initiated by the addition of enzyme. Reactions were incubated at 30°C for 45 min, and stopped by adding 30 ul of 20% ice cold TCA. Plates were chilled for 30 minutes and harvested onto Unifilter-96, GF/B plates(Packard, 6005177) using a Packard FilterMate Cell Harvester. The harvest plates were prewashed 3 times, 200ul/well, with 100 mM NaPPi. Harvested filters were washed 30 times, 200 ul/well, with distilled water followed by ethanol. Filter plates were dried, and 30 ul /well microscint-20 was added. Plates were read on a Packard Top Count NXT.

The IC_{50} values for compounds were determined using six different [I], combined with 7nM enzyme, 800 ng of the template-primer polyC/oligoG_{12} (1:5 molar ratio), and 0.7 uM of ^{3}H GTP containing 1 uCi. The observed fractional activity (fa = vi/vo) was used in the equation IC_{50} = [I]/(1/fa-1) to determine a single point IC_{50} value. Typically, the single point IC_{50} values derived from [I] that produced fractional activities in the range of 0.1 to 0.8 relative to the uninhibited control were averaged to calculate the IC_{50} value for each compound.

FRET Assay Preparation. To perform the HCV FRET screening assay, 96-well cell culture plates were used. The FRET peptide (Anaspec, Inc.) (Taliani et al., Anal. Biochem. 240:60-67 (1996), expressly incorporated by reference in its entirety) contains a fluorescence donor, EDANS, near one end of the peptide and an acceptor, DABCYL, near the other end. The fluorescence of the peptide is quenched by intermolecular resonance energy transfer (RET) between the donor and the acceptor,

but as the NS3 protease cleaves the peptide the products are released from RET quenching and the fluorescence of the donor becomes apparent.

The assay reagent was made as follows: 5X cell Luciferase cell culture lysis reagent from Promega (#E153A) diluted to 1X with dH_2O, NaCl added to 150 mM final, the FRET peptide diluted to 20 uM final from a 2 mM stock. Cells were trypsinized, placed into each well of a 96-well plate and allowed to attach overnight. The next day, the test compounds were added to columns 1 through 10; column 11 was media only, and column 12 contained a titration of interferon as a control (1000units for A12, B12, 100units for C12, D12, 10units for E12, F12 and 1unit for G12, H12). The plates were then placed back in the incubator.

FRET Assay and Cytotoxicity Assay. Subsequent to addition of the test compounds described above (FRET Assay Preparation), at various times the plate was removed and Alamar blue solution (Trek Diagnostics, #00-100) was added per well as a measure of cellular toxicity. After reading in a Cytoflour 4000 instrument (PE Biosystems), plates were rinsed with PBS and then used for FRET assay by the addition of 30 ul of the FRET peptide assay reagent described above (FRET Assay Preparation) per well. The plate was then placed into the Cytoflour 4000 instrument which had been set to 340 excite/490 emission, automatic mode for 20 cycles and the plate read in a kinetic mode. Typically, the signal to noise using an endpoint analysis after the reads was at least three-fold.

Compound analysis was determined by quantification of the relative HCV replicon inhibition and the relative cytotoxicity values. To calculate cytoxicity values, the average Alamar Blue fluorescence signals from the control wells in row 11 were set as 100% non-toxic. The individual signals in each of the compound test wells were then divided by the average control signal and multiplied by 100% to determine percent cytotoxicity. To calculate the HCV replicon inhibition values, an average background value FRET signal was obtained from the two wells containing the highest amount of interferon at the end of the assay period. These numbers were similar to those obtained from naïve Huh-7 cells.

The background numbers were then subtracted from the average FRET signal obtained from the control wells in row 11 and this number was used as 100% activity. The individual signals in each of the compound test wells were then divided by the averaged control values after background subtraction and multiplied by 100% to determine percent activity. EC_{50} values for an interferon titration were calculated as the concentration which caused a 50% reduction in HCV RNA, HCV protein amounts or FRET activity. The two numbers generated for the compound plate, percent cytoxicity and percent activity were used to determine compounds of interest for further analysis.

The HCV NS5B RdRp enzyme inhibition assay results are tabulated in Table 1.

Table 1.

Example	RdRp Inhibition IC_{50} (μM)
1	> 25
2	> 25
3	15
4	> 25
5	0.45
6	> 25
7	10
8	> 25
9	0.27
10	> 25
11	> 25
12	> 25
13	0.38
14	> 25
15	> 25
16	> 25
17	1.8
18	> 25
19	4.9
20	> 25
21	2.3
22	> 25
23	> 25
24	3.1
25	> 25
27	> 25
28	1.3
29	> 25
30	> 25
31	4.5
32	> 25

Example	RdRp Inhibition IC_{50} (μM)
33	2.4
34	> 25
35	> 25
36	> 25
38	> 25
39	4.0
40	> 25
41	10
42	> 25
43	0.31
44	> 25
45	6.6
46	> 25
47	> 25
48	5.3
49	> 25
50	15
51	> 25
52	2.5
53	> 25
54	1.6

Pharmaceutical Compositions and Methods of Use

The compounds of this invention inhibit HCV NS5B RNA-dependent RNA polymerase (RdRp). This polymerase is one of a small number of functional enzymes encoded by the viral RNA and is known to be essential for infectivity of chimpanzees. By inhibiting this enzyme, the compounds of this invention are useful for impeding or preventing HCV infection and for treating hepatitis C. At least one other compound which acts on this enzyme is currently undergoing clinical evaluation for hepatitis C (Tan, S.-L.; Pause, A.; Shi, Y.; Sonenberg, N. *Nature Reviews/Drug Discovery* **2002**, *1*, 867-881).

The compounds of this invention are generally given as pharmaceutical compositions comprised of a therapeutically effective amount of a compound of Formula I or its pharmaceutically acceptable salt and a pharmaceutically acceptable carrier and may contain conventional exipients. A therapeutically effective amount is that which is needed to provide a meaningful patient benefit. Pharmaceutically acceptable carriers are those conventionally known carriers having acceptable safety profiles. Compositions encompass all common solid and liquid forms including

capsules, tablets, losenges, and powders as well as liquid suspensions, syrups, elixers, and solutions. Compositions are made using common formulation techniques, and conventional excipients (such as binding and wetting agents) and vehicles (such as water and alcohols) are generally used for compositions. Compositions are normally formulated in dosage units and compositions providing from about 1 to 1000 mg of the active ingredient per dose are preferred.

Methods of treatment involve administering a therapeutically effective amount of a Formula I compound or a pharmaceutically acceptable salt to a patient exhibiting conditions responsive to HCV NS5B RdRp inhibition. The methods include all conventional modes of administration. Typical modes are oral, topical, rectal, nasal, and parenteral. Generally, the daily dosage will be from about 0.001 mg to 100 mg of Formula I compound per kilogram of bodyweight when used for hepatitis C. The specific dosing regimen, however, must be carefully adjusted using sound medical judgement.

The compounds of this invention can be used with other agents that inhibit HCV viral replication including replicase inhibitors, metalloprotease inhibitors, NS3 protease inhibitors, NS3 helicase inhibitors, NS5A inhibitors–including interferons (IFN), PEGylated interferons, and ribavirin–and NS5B polymerase inhibitors.

Additionally, the compounds can be used in conjunction with other hepatitis C compounds including inosine monophophate dehydrogenase (IMPDH) inhibitors, immune modulators, serine protease inhibitors, immunoglobulin immunosuppressants, antivirals, antifibrotics, caspase inhibitors, and tubulin inhibitors, as well as monoclonal antibodies, ribozymes, and antisense agents.

The table below lists some compositions that can be administered with the compounds of this invention. The compounds of this invention can be administered with these compositions in combination therapy –either jointly or separately–or by combining the compounds with one or more of the compositions into a new composition.

Table 2.

Compound Name	Catagory	Company
Omega IFN	IFN-ω	BioMedicines Inc., Emeryville, CA
BILN-2061	serine protease inhibitor	Boehringer Ingelheim Pharma KG, Ingelheim, Germany
Summetrel	antiviral	Endo Pharmaceuticals Holdings Inc., Chadds Ford, PA
Roferon A	IFN-α2a	F. Hoffmann-La Roche LTD, Basel, Switzerland
Pegasys	PEGylated IFN-α2a	F. Hoffmann-La Roche LTD, Basel, Switzerland
Pegasys and Ribavirin	PEGylated IFN-α2a/ribavirin	F. Hoffmann-La Roche LTD, Basel, Switzerland
CellCept	HCV IgG immunosuppressant	F. Hoffmann-La Roche LTD, Basel, Switzerland
Wellferon	lymphoblastoid IFN-αn1	GlaxoSmithKline plc, Uxbridge, UK
Albuferon - α	albumin IFN-α2b	Human Genome Sciences Inc., Rockville, MD
IDN-6556	caspase inhibitor	Idun Pharmaceuticals Inc., San Diego, CA
IP-501	antifibrotic	Indevus Pharmaceuticals Inc., Lexington, MA
Actimmune	INF-γ	InterMune Inc., Brisbane, CA
Infergen A	IFN alfacon-1	InterMune Pharmaceuticals Inc., Brisbane, CA
ISIS 14803	antisense	ISIS Pharmaceuticals Inc, Carlsbad, CA/Elan Phamaceuticals Inc., New York, NY
JTK-003	RdRp inhibitor	Japan Tobacco Inc., Tokyo, Japan
Pegasys and Ceplene	PEGylated IFN-α2a/ immune modulator	Maxim Pharmaceuticals Inc., San Diego, CA
Ceplene	immune modulator	Maxim Pharmaceuticals Inc., San Diego, CA
Civacir	HCV IgG immunosuppressant	Nabi Biopharmaceuticals Inc., Boca Raton, FL
Intron A and Zadaxin	IFN-α2b/α1-thymosin	RegeneRx Biopharmiceuticals Inc., Bethesda, MD/ SciClone Pharmaceuticals Inc, San Mateo, CA
Levovirin	IMPDH inhibitor	Ribapharm Inc., Costa Mesa, CA
Viramidine	IMPDH inhibitor	Ribapharm Inc., Costa Mesa, CA
Heptazyme	ribozyme	Ribozyme Pharmaceuticals Inc., Boulder, CO
Intron A	IFN-α2b	Schering-Plough Corporation, Kenilworth, NJ
PEG-Intron	PEGylated IFN-α2b	Schering-Plough Corporation, Kenilworth, NJ
Rebetron	IFN-α2b/ribavirin	Schering-Plough Corporation, Kenilworth, NJ

Compound Name	Catagory	Company
PEG-Intron / Ribavirin	PEGylated IFN-α2b/ribavirin	Schering-Plough Corporation, Kenilworth, NJ
Zadazim	immune modulator	SciClone Pharmaceuticals Inc., San Mateo, CA
Rebif	IFN-β1a	Serono, Geneva, Switzerland
IFN-β and EMZ701	IFN-β and EMZ701	Transition Therapeutics Inc., Ontario, Canada
T67	β-tubulin inhibitor	Tularik Inc., South San Francisco, CA
VX-497	IMPDH inhibitor	Vertex Pharmaceuticals Inc., Cambridge, MA
VX-950/LY-570310	serine protease inhibitor	Vertex Pharmaceuticals Inc., Cambridge, MA/ Eli Lilly and Co. Inc., Indianapolis, IN
Omniferon	natural IFN-α	Viragen Inc., Plantation, FL
XTL-002	monoclonal antibody	XTL Biopharmaceuticals Ltd., Rehovot, Isreal

DESCRIPTION OF SPECIFIC EMBODIMENTS

Abbreviations

Solution ratio express a volume relationship, unless stated otherwise. NMR chemical shifts (δ) are reported in parts per million. Flash chromatography was carried out on silica gel according to Still's method (Still, W. C. *et al. J. Org. Chem.* (1978), 43, 2923). Abbreviations used in the Examples are defined as follows: "°C" for degrees Celsius, "MS" for mass spectrometry, "ESI" for electrospray ionization mass spectroscopy, "HR" for high resolution, "LC-MS" for liquid chromatography mass spectrometry, "eq" for equivalent or equivalents, "g" for gram or grams, "h" for hour or hours, "mg" for milligram or milligrams, "ml" for milliliter or milliliters, "mmol" for millimolar, "M" for molar, "min" for minute or minutes, "HPLC" for high pressure liquid chromatography, "rt" for room temperature, "NMR" for nuclear magnetic resonance spectroscopy, "tlc" for thin layer chromatography, "atm" for atmosphere, and "α", "β", "R", "S", "E", and "Z" are stereochemical designations familiar to one skilled in the art.

As used throughout the specification, the following abbreviations for chemical reagents apply:

Boc is *tert*-butyl oxycarbonyl,

BuLi is n-butyl lithium

Cbz is carbonylbenzyloxy,

DCE is 1,2-dichloroethane,

DIEA is diethylpropyl amine,

DMAP is dimethylaminopyridine,

DME is dimethylethyleneglycol

DMF is dimethylformamide,

EDCI is 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride,

HOAt is 1-hydroxy-7-azabenzotriazole,

LiHMDS is bis(trimethylsilyl)amide,

NBS is N-bromosuccinamide,

NCS is N-chlorosuccinamide,

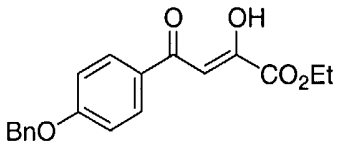
TBAI is tetrabutylammonium iodide,

TEA is triethylamine,

TFA is trifluoroacetic acid,

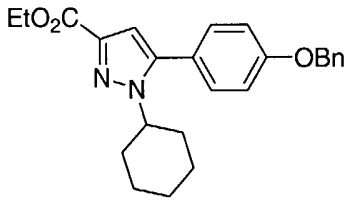
THF is tetrahydrofuran.

Intermediate 1.2



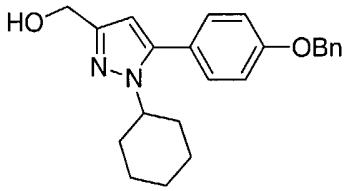
Ethyl (2*Z*)-2-hydroxy-4-oxo-4-(4-benzyloxyphenyl)-2-butenoate (1.2). To a solution of 4-benzyloxyacetophenone **1.1** (20.0 g, 88.4 mmol) in DMF (100 ml) at rt, was added NaH (60% in oil, 4.26 g, 106 mmol). The mixture was stirred at rt for 45 min, cooled to 0°C, and diethyl oxalate (14.4 ml, 106 mmol) was added dropwise, and the suspension warmed to rt and stirred for 17 h. The reaction mixture was poured over a mixture of ice and 1N HCl and the suspension stirred for 30 min, filtered, and the solid rinsed with water and dried to afford 28.9 g of the butenoate **1.2**. MS (ESI) 325.2 (MH^+).

Example 1



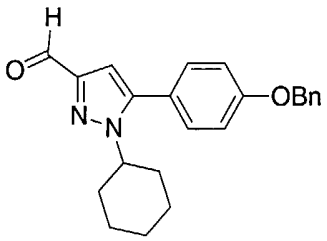
Ethyl 1-cyclohexyl-5-(4-benzyloxyphenyl)-1*H*-pyrazole-3-carboxylate (1.3). The butenoate **1.2** (5.00 g, 15.3 mmol) and cyclohexylhydrazine hydrochloride (2.77 g, 18.4 mmol) were heated at refluxed in EtOH (60 ml) for 2h. Concentration *in vacuo* resulted in formation of a solid which was suspended in EtOAc and filtered through a 1" pad of SiO_2, elution with ethyl acetate. The filtrate was concentrated to afford 6.10 g (98%) of the desired pyrazole ester **1.3**. MS (ESI) 405.4 ($M + H^+$).

Intermediate 2.1



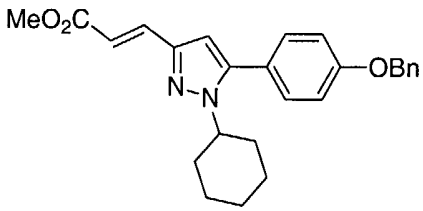
[1-cyclohexyl-5-(4-benzyloxyphenyl)-1*H*-pyrazol-3-yl]methanol (2.1). To a suspension of LAH (52 mg, 1.36 mmol) in THF (6 ml) at 0°C, was added dropwise a solution of pyrazole ester **1.3** (500 mg, 1.24 mmol) in THF (3 ml). The mixture was stirred at 0°C for 30 min, quenched with H_2O, diluted with 1N HCl, and extracted with EtOAc (3X). The combined organic phase was washed with H_2O, brine, and dried (Na_2SO_4). Filtration through a 1" pad of SiO_2, elution with ethyl acetate, and concentration of the filtrate afforded 448 mg (100%) alcohol **2.1**. HRMS (ESI) calc'd for $C_{23}H_{27}N_2O_2$ 363.1994; found 363.2083 (MH^+).

Intermediate 2.2



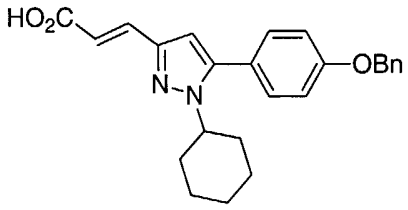
1-cyclohexyl-5-(4-benzyloxyphenyl)-1*H*-pyrazole-3-carbaldehyde (2.2). To a solution of alcohol **2.1** (400 mg, 1.10 mmol) in DME (10 ml) at reflux, was added MnO_2 (880 mg), portion-wise over 4 h. After being cooled to rt, the solution was concentrated and the crude product filtered though a 1" pad of SiO2, elution with ethyl acetate. The filtrate was concentrated to give aldehyde **2.2** 260 mg (91%). HRMS (ESI) calc'd for $C_{23}H_{25}N_2O_2$ 361.1838; found 361.1926 (MH^+).

Example 2



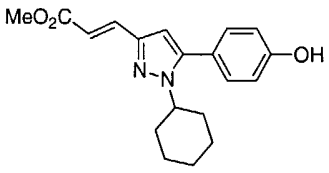
Methyl (2*E*)-3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-propenoate (2.3). A mixture of aldehyde **2.2** (311 mg, 0.863 mmol) and methyl (triphenylphosphoranyl-idene)acetate (317 mg, 0.949 mmol) in benzene (5 ml) were heated at reflux for 6 h. Additional methyl (triphenylphosphoranylidene)acetate (100 mg) was added and the mixture and after an addition 18 h at reflux, the reaction mixture was concentrated to give a residue purified by SiO_2 chromatography (stepwise gradient, 10 to 15% EtOAc/hexanes) to afford **2.3,** 300 mg (83%). MS (ESI) 417.4 ($M + H^+$).

Example 3



(2*E*)-3-[1-cyclohexyl-5-(4-benzyloxyphenyl)-1*H*-pyrazol-3-yl]-2-propenoic acid (2.4). To a solution of ester **2.3** (55 mg, 0.132 mmol) in 4.5 ml of THF/MeOH (8:1) was added 1N LiOH (2 ml), and the mixture was stirred for 24 h at rt. Concentration to remove solvent gave a residue that was taken Et_2O and extracted with 0.1 N NaOH and H_2O (2X). The combined aqueous extracts were acidified with concentrated HCl and extracted with EtOAc (3X). The combined organic extracts were washed with H_2O, brine, dried (Na_2SO_4). The crude product was triturated with hexanes to afford 45.8 mg (86%) of acid **2.4**. HRMS (ESI) calc'd for $C_{25}H_{27}N_2O_3$ 403.1943; found 403.2019 (MH^+); ^1H NMR (300 MHz, $CDCl_3$) δ 7.83 (d, J = 16.1, 1H), 7.49-7.34 (m, 5H), 7.28 (d, J = 8.8, 2H), 7.07 (d, J = 8.8, 2H), 6.46 (s, 1H), 6.38 (d, J = 15.7, 1H), 5.13 (s, 2H), 4.14-4.04 (m, 1H), 2.03-1.82 (m, 6H), 1.28-1.24 (m, 4H).

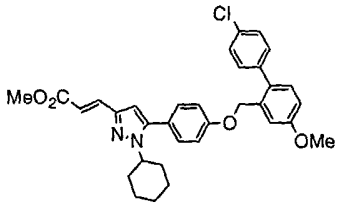
Intermediate 3.1



Methyl (2*E*)-3-[1-cyclohexyl-5-(4-hydroxyphenyl)-1*H*-pyrazol-3-yl]-2-propenoate (3.1). To a solution of ester **2.3** (50 mg, 0.120 mmol) in CH_2Cl_2 (2 ml) at -50°C was added a 1M solution of BCl_3 in CH_2Cl_2 (600 µl 0.60 mmol), and the mixture was stirred for 30 min at that temperature before being quenched with MeOH, diluted with EtOAc, washed with H_2O, saturated $NaHCO_3$ (2X), brine, and dried (Na_2SO_4). After concentration, the residue was combined with another 0.024

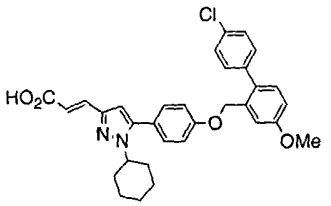
mmol batch for purification by SiO_2 chromatography (30% EtOAc/hexanes) to afford 48 mg (100%) of phenol **3.1**. MS (ESI) 327.3 (MH^+), 325.3 (MH^-).

Example 4



Methyl (2*E*)-3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-propenoate (3.2). A mixture of phenol **3.1** (34 mg, 0.104 mmol), 4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methyl bromide (39.0 mg, 0.125 mmol), and powdered K_2CO_3 (28.7 mg, 0.208 mmol) were heated at refluxed for 1.5 h in CH_3CN (3 ml). The mixture was poured into EtOAc, washed with water, brine, and dried (Na_2SO_4). Purification by SiO_2 chromatography (stepwise gradient: 15 to 20% EtOAc/hexanes) gave **3.2**, 52 mg (93%). MS (ESI) 557.3 (MH^+).

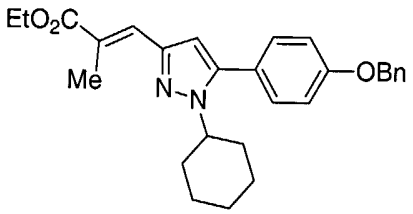
Example 5



(2*E*)-3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-propenoic acid (3.3). Methyl ester **3.2** (40 mg) and 1N LiOH (1 ml) in 3 ml MeOH/THF (1:2) was stirred at rt 18 h before being concentrated and partitioned between EtOAc and H_2O. The aqueous layer was acidified with 1N HCl and extracted with EtOAc (3X). The organic extracts were washed with H_2O, brine, and dried (Na_2SO_4). Concentration gave **3.3**, 39 mg

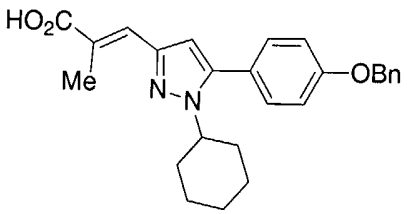
(100%). HRMS (ESI) calc'd for $C_{32}H_{32}ClN_2O_4$ 542.1972; found 543.2050 (MH^+); ^1H NMR (300 MHz, $CDCl_3$) δ 7.83 (d, J = 15.8, 1H), 7.39-7.23 (m, 7H), 7.18 (d, J = 2.6, 1H), 6.99-6.94 (m, 3H), 6.45 (s, 1H), 6.38 (d, J = 6.1, 1H), 4.94 (s, 2H), 4.13-4.01 (m, 1H), 3.88 (s, 3H), 2.04-1.83 (m, 6H), 1.32-1.21 (m, 4H).

Example 6



Ethyl (2*E*)-3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-methyl-2-propenoate (4.1). BuLi (1.6 M in hexanes, 956 μL, 1.53 mmol) was added dropwise to (1-ethoxycarbonyl-thyl)triphenylphosphonium bromide (738 mg, 1.66 mmol) in THF (7 ml) at 0°C, follow by addition of aldehyde **2.2** (500 mg, 1.39 mmol as solution in 3 ml of THF). The mixture was stirred at 0°C for 30 min and warmed to rt, and after 1.5 h, H_2O was added. The mixture was diluted with EtOAc, and the organic phase was washed with H_2O, brine, dried (Na_2SO_4). After being concentrated, the resultant residue was purified by SiO_2 chromatography (gradient elution: 10 to 15% EtOAc/hexanes) to provide 530 mg (86%) of **4.1**. MS (ESI) 445.4 (MH^+).

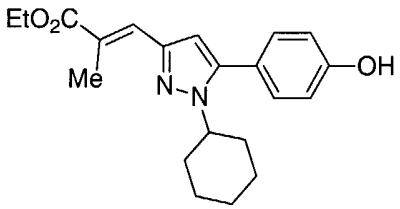
Example 7



(2*E*)-3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-methyl-2-propenoic acid (4.2). A mixture of methyl ester **4.1** (50 mg, 0.112 mmol) and 1N

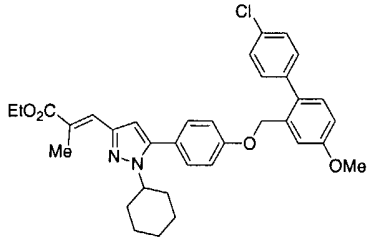
LiOH (2 ml) in 3 ml of MeOH/THF (1:2) was stirred at rt for 18 h, concentrated, and partitioned between Et_2O and H_2O. The organic phase was extracted with 0.1 N NaOH (2X), and the combined aqueous extracts were acidified with conc. HCl, and extracted with EtOAc (3X). The combined organic extracts were washed with H_2O, brine, and dried (Na_2SO_4) before being concentrated to afford 47 mg (100%) of **4.2**. HRMS (ESI) calc'd for $C_{26}H_{29}N_2O_3$ 417.2178, found 417.2174 (MH^+); ^1H NMR (300 MHz, $CDCl_3$) δ 7.81 (d, *J* = 1.1, 1H), 7.49-7.36 (m, 5H), 7.30 (d, *J* = 8.7, 2H), 7.07 (d, *J* = 8.7, 2H), 6.45 (s, 1H), 5.14 (s, 2H), 4.14-4.07 (m, 1H), 2.26 (d, *J* = 1.5, 3H), 2.07-2.00 (m, 2H), 1.95-1.84 (m, 4H), 1.36-1.22 (m, 4H).

Intermediate 4.3



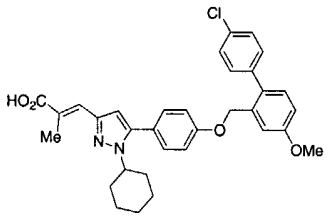
Ethyl (2*E*)-3-[1-cyclohexyl-5-(4-hydroxyphenyl)-1*H*-pyrazol-3-yl]-2-methyl-2-propenoate (4.3). To a solution **4.1** (83 mg, 0.187 mmol) in CH_2Cl_2 (2 ml) at -50°C was added a 1M solution of BCl_3 in CH_2Cl_2 (933 µL, 0.933 mmol) followed by stirring at -50°C for 15 min, and quenched with MeOH. The mixture was diluted with EtOAc, washed with H_2O, sat. $NaHCO_3$, brine, and dried (Na_2SO_4). Filtration through a 1" pad of SiO_2 and concentration to provided **4.3,** 67 mg (100%). MS (ESI) 355.3 (MH^+), 353.3 (MH^-).

Example 8



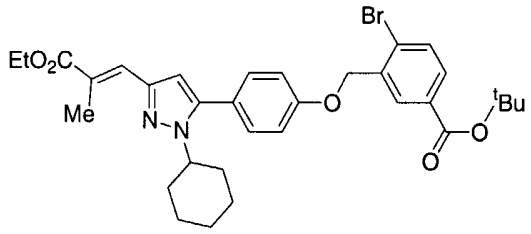
Ethyl (2*E*)-3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoate (4.4). A mixture of ethyl ester **4.3** (40.8 mg, 0.114 mmol), 4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methyl bromide (42.7 mg, 0.137 mmol), and powdered K_2CO_3 (31.5 mg, 0.228 mmol) were taken up in CH_3CN (2 ml) and heated at reflux for 2 h prior to being poured into EtOAc, washed with water, brine, and dried (Na_2SO_4). Concentration and purification by SiO_2 chromatography (stepwise gradient: 5 to 7.5 to 10 to 12.5% EtOAc/hexanes) to gave 67 mg (100 %) of **4.4**. MS (ESI) 585.4 (MH^+).

Example 9



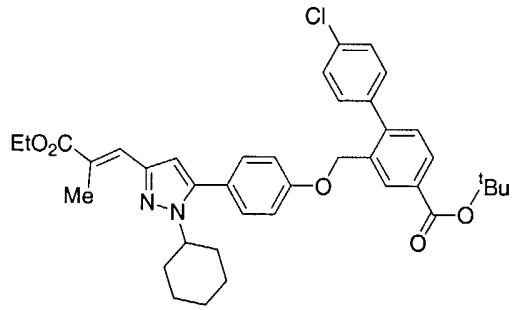
(2*E*)-3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoic acid (4.5). Ethyl ester **4.4** (55 mg, 0.094 mmol) was stirred with 1N LiOH (1 ml) in 4 ml of MeOH/THF (1:3) at rt for 24 h, concentrated, and partitioned between Et_2O and H_2O. The organic phase was extracted with 0.1 N NaOH (2X), and the combined aqueous extracts were acidified with conc. HCl and extracted with EtOAc (3X). The combined organic extracts were washed with H_2O, brine, and dried (Na_2SO_4). Concentration gave a crude product which was purified by semi-preparative HPLC (gradient elution: 70 to 100% CH_3CN/H_2O + 0.1% TFA) to give **4.5,** 47 mg (90%). HRMS (ESI) calc'd for $C_{33}H_{34}ClN_2O_4$ 577.2207, found 557.2218 (MH^+); ^1H NMR (300 MHz, $CDCl_3$) δ 7.83 (d, J = 1.1, 1H), 7.39-7.25 (m, 7H), 7.19 (d, J = 2.5, 1H), 7.00-6.95 (m, 3H), 6.47 (s, 1H), 4.95 (s, 2H), 4.14-4.05 (m, 1H), 3.88 (s, 3H), 2.24 (s, 3H), 2.10-1.98 (m, 2H), 1.94-1.87 (m, 4H), 1.27-1.22 (m, 4H).

Example 10



Ethyl (2*E*)-3-(5-{4-[(*t*-butyl-2-bromo-5-phenylcarboxylate)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoate (5.1). Phenol **4.3** (116 mg, 0.33 mmol) was dissolved in of DMF (3.2 ml), cesium carbonate (341 mg, 1.05mmol), and bromide (120mg, 0.34 mmol) were added, and the reaction was stirred for 18 h at rt under N_2. Solvent was removed *in vacuo*, and the residue partitioned between ethyl acetate and water. The organic layer was washed with brine, dried ($MgSO_4$), and concentrated. Purification by silica gel chromatography (stepwise gradient; 7% to 25% EtOAc / Hexanes) gave a colorless amorphous solid 124 mg (60%) of **5.1**. MS (ESI) 625.3 (MH^+).

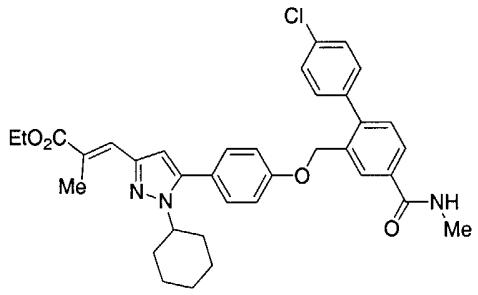
Example 11



Ethyl (2E)-3-(5-{4-[(4'-chloro-4-t-butoxycarbonyl-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-pyrazol-3-yl)-2-methyl-2-propenoate (5.2). Bromide **5.1** (120mg, 0.19 mmol) and 4-chlorophenylboronic acid (33 mg, 0.21 mmol) were admixed in a 2 dram vial containing anhydrous THF (1.9 ml) and saturated $NaHCO_3$ solution (1.1 ml) and the solution sparged with N_2 prior to addition of tetrakis(triphenylphosphine) palladium 0 (24 mg, 0.02mmol). The reaction was heated to 80°C for 18 h, cooled, partitioned between EtOAc and water,

and the organic layer washed with brine, and dried ($MgSO_4$). Purificaion by silica gel chromatography (stepwise gradient: 5% to 25% EtOAc/Hexanes) yielded 103 mg (82%) of **5.2**. MS (ESI) 655.3 (MH+).

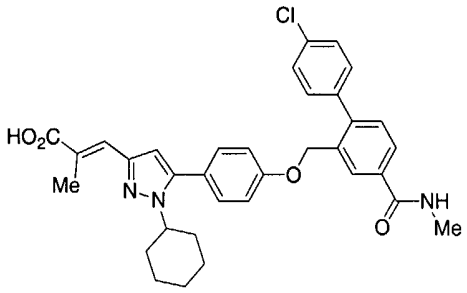
Example 12



Ethyl (2*E*)-3-(5-{4-[(4'-Chloro-4-N-methylcarbamoyl-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoate (5.3).

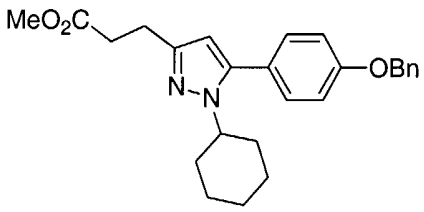
Ester **5.2** (103 mg, 0.157 mmol) was dissolved in dicholormethane (5 ml) and after trifluoroacetic acid (5 ml) was added under N_2 the reaction was capped and stirred for 2 h. Volatiles were removed *in vacuo* (co-evaporate with toluene) and the residue was placed on high vacuum 1 h to remove trace moisture [MS (ESI) 599.2 (MH+)], and the dried was dissolved in DMF (2.5 ml). Diisopropylethylamine (0.186 ml), O-benzotriazol-1-yl-N,N,N',N'-tetramethyluronium tetrafluoroborate (TBTU) (85 mg, 0.26mmol) were added and the solution stirred for 10 min. An aliquot (0.675 ml, 0.043 mmol) of the solution was partitioned into 2 dram vial and N-methylamine (0.3 mmol, 7eq, gas) amine added. The reaction was stirred under N_2 for 16 h, solvent removed *in vacuo* and residue purified by chromatography (ISCO Optix 10 system equipped with 4.2g silica gel redi-sep cartridges) to give 17.4 mg (66%) of **5.3**. MS (ESI) 626.2 (MH+).

Example 13



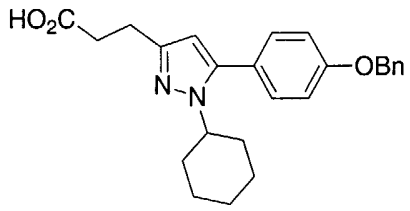
(2*E*)-3-(5-{4-[(4'-Chloro-4-N-methylcarbamoyl-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoic acid (5.4). Ester **5.3** (12.1 mg, 0.02 mmol) was dissolved in THF (0.25 ml), 1N sodium hydroxide (0.04 ml, 0.04 mmol) added, and the reaction mixture heated at 60°C for 5.5 h. The solvent was removed in vacuo and the residue partitioned between EtOAc and 1N HCl. The organic layer was washed with brine and dried (MgSO4), and concentrated to give 11 mg (95%) of **5.4**. HRMS (ESI) calc'd for $C_{34}H_{35}ClN_3O_4$ 584.2316, found 584.2303 (MH+); 1H NMR (300 MHz, CDCl3) δ 8.05 (d, *J* = 2.5, 1H), 7.80 (dd, *J* = 3.0, 9.1, 1H), 7.78 (s, 1H), 7.42-7.28 (m, 7H), 6.95 (d, *J* = 9.0, 2H), 6.43 (s, 1H), 4.97 (s, 2H), 3.05 (d, *J* = 6.0, 3H), 2.25 (s, 3H), 2.10-1.65 (m, 6H), 1.29-1.21 (m, 5H).

Example 14



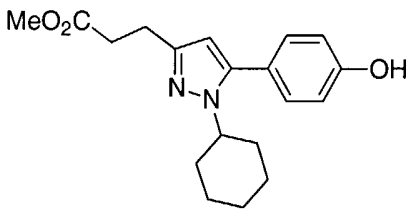
Methyl 3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}propanoate (6.1). To a solution of methyl ester **2.3** (52 mg, 0.125 mmol) in benzene (5 ml), was added 10 mg of 10% Pd-C. The atmosphere was evacuated and flushed with H_2 gas (3X), and the solution stirred for 1.5 h. The mixture was filtered and concentrated to give 52 mg (100%) of **6.1**. MS (ESI) 419.4 ($M + H^+$).

Example 15



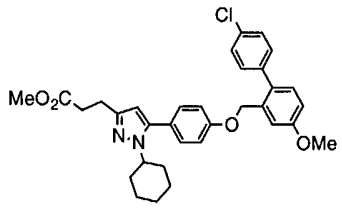
3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}propanoic acid (6.2). Methyl ester **6.1** (53 mg) was stirred with 1N LiOH (2 ml) in 5 ml of MeOH/THF (4:1) over 18 h, concentrated, and partitioned between Et_2O and H_2O. The organic phase was extracted with 0.1 N NaOH (2X), and the combined aqueous extracts were acidified with conc. HCl and extracted with EtOAc (3X). The organic extracts were washed with H_2O, brine, and dried (Na_2SO_4). The residue after concentration was triturated with hexanes/ Et_2O (10:1) to afford acid **6.2,** 39 mg (100%). HRMS (ESI) calc'd for $C_{25}H_{29}N_2O_3$ 405.2100, found 405.2198 (MH^+); MS (ESI); ^1H NMR (300 MHz, $CDCl_3$) δ 7.48-7.34 (m, 5H), 7.27 (d, J = 7.0, 2H), 7.06 (d, J = 8.7, 2H), 6.01 (s, 1H), 5.13 (s, 2H), 4.06-3.98 (m, 1H), 3.02-2.97 (m, 2H), 2.85-2.81 (m, 2H), 1.91-1.83 (m, 6H), 1.26 (br s, 4H).

Intermediate 6.3



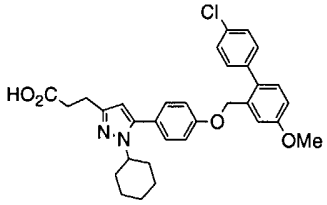
Methyl 3-[1-cyclohexyl-5-(4-hydroxyphenyl)-1*H*-pyrazol-3-yl]propanoate (6.3). To a solution of methyl ester **6.1** (71.5 mg, 0.172 mmol) in MeOH (4 ml) was added 20 mg 10% Pd-C prior to atmosphere evacuation and flushed with H_2 (3X). The reaction mixture was stirred under H_2 for 2 h, filtered, and concentrated to give 54 mg (96%) of **6.3**. MS (ESI) 329.3 (MH^+), 327.3 (MH^-).

Example 16



Methyl 3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)propanoate (6.4). A mixture **6.3** (39 mg, 0.119 mmol), 4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methyl bromide (44.4 mg, 0.143 mmol), and powdered K_2CO_3 (32.9 mg, 0.238 mmol) in CH_3CN (2 ml) was heated at reflux for 1.5 h. The reaction mixture was filtered, poured into EtOAc, washed with water, brine, and dried (Na_2SO_4). Conentration purification by SiO_2 chromatography (stepwise gradient: 20 to 25% EtOAc/hexanes) to afforded **6.4**, 66 mg (100%). MS (ESI) 559.5 (MH^+).

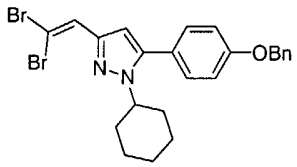
Example 17



3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)propanoic acid (6.5). Methyl ester **6.4** (50 mg, 0.092) was stirred with 1N LiOH (2 ml) in 3 ml of MeOH/THF (2:1) at rt for 15 h, concentrated, and partitioned between Et_2O and H_2O. The organic phase was extracted with 0.1 N NaOH (2X), and the combined aqueous extracts were acidified with conc. HCl and extracted with EtOAc (3X). The combined organic extracts were washed with H_2O, brine, dried (Na_2SO_4). The residue from concentration was purified by SiO_2 chromatography (stepwise gradient: 50 to 60 to 70% EtOAc/hexanes) to yield **6.5,** 31.6 mg (65%). HRMS (ESI) calc'd for $C_{32}H_{34}ClN_2O_4$ 545.2129, found 545.2204 (MH^+); ^1H NMR (300 MHz, $CDCl_3$) δ 7.38-7.17 (m, 8H),

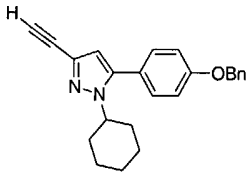
6.99-6.93 (m, 3H), 6.00 (2, 1H), 4.94 (s, 2H), 4.05-3.97 (m, 1H), 3.88 (s, 3H), 3.01-2.97 (m, 2H), 2.85-2.80 (m, 2H), 1.90-1.83 (m, 6H), 1.25 (br s, 4H).

Intermediate 7.1



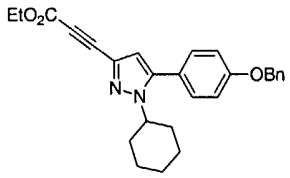
5-[4-(Benzyloxy)phenyl]-1-cyclohexyl-3-(2,2-dibromovinyl)-1*H*-pyrazole (7.1). To a solution of CBr_4 (916 mg, 2.76 mmol) in 7 ml of CH_2Cl_2 at 0°C, was added PPh_3 (1.45 g, 5.52 mmol), and the mixture was stirred at 0°C for 10 min before addition of aldehyde **2.2** (500 mg, 1.38 mmol as a solution in 2 ml of CH_2Cl_2). The mixture was stirred at 0°C for 30 min, diluted with hexanes, filtered through a 1" pad of SiO_2 eluting with 10% EtOAc/hexanes. The filtrate was concentrated and the resultant residue purified by SiO_2 chromatography (5% EtOAc/hexanes) to afford **7.1**, 648 mg (91%). MS (ESI) 515.1 (MH^+).

Intermediate 7.2



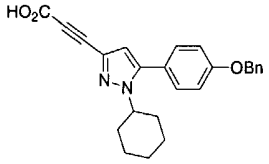
5-[4-(benzyloxy)phenyl]-1-cyclohexyl-3-ethynyl-1*H*-pyrazole (7.2). n-Butyllithium (1.6 M BuLi in hexanes, 1.65 ml, 2.64 mmol) was added dropwise to a solution of **7.1** (620 mg, 1.20 mmol) in THF (6 ml) at -50°. The mixture was stirred at -50°C for 30 min, quenched with H_2O, diluted with EtOAc, washed with 1N HCl, H_2O, brine, and dried (Na_2SO_4). The crude product was purified by SiO_2 chromatography to afford 261 mg (61%) of **7.2**. MS (ESI) 357.3 (MH^+).

Example 18



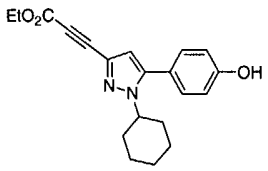
Ethyl 3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-propynoate (7.3). To a solution **7.2** (181 mg, 0.508 mmol) in 4 ml of THF at -78°C was added BuLi (1.6 M in hexanes, 349 µL, 0.559 mmol), and the solution was stirred at -78°C for 15 min, followed by additon of ethyl chloroformate (73 µL, 0.762 mmol). The mixture was allowed to warm to 0°C over 30 min, quenched with H_2O, diluted with EtOAc, washed with H_2O, brine, and dried (Na_2SO_4). The mixture was combined with another 0.141 mmol batch for purification by SiO_2 chromatography (stepwise gradient: 5 to 7.5 to 10 to 12.5% EtOAc/hexanes) to give **7.3**, 214 mg (77%). MS (ESI) 429.4 (MH^+).

Example 19



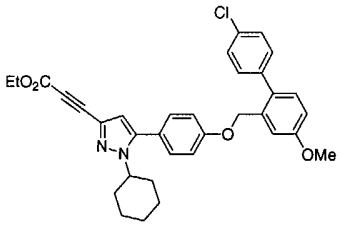
3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-propynoic acid (7.4). A mixture of ester **7.3** (68 mg, 0.157 mmol) and 1N LiOH (2 ml) in 6 ml MeOH/THF (1:2) was stirred at rt for 24 h, concentrated, and partitioned between Et_2O and H_2O. The organic phase was extracted with 0.1 N NaOH (2X), and the combined aqueous extracts were acidified with conc. HCl, and extracted with EtOAc (3X). The combined organic extracts were washed with H_2O, brine, and dried (Na_2SO_4) to afford 64 mg (100%) of acid **7.4**. HRMS (ESI) calc'd for $C_{25}H_{25}N_2O_3$ 401.1865, found 401.1855 ($M + H^+$); ^1H NMR (300 MHz, $CDCl_3$) δ 7.48-7.37 (m, 5H), 7.26 (d, J = 8.8, 2H), 7.08 (d, J = 8.8, 2H), 6.51 (s, 1H), 5.13 (s, 2H), 4.15-4.06 (m, 1H), 2.05-1.97 (m, 2H), 1.90-1.87 (m, 4H), 1.28-1.23 (m, 4H).

Intermediate 7.5



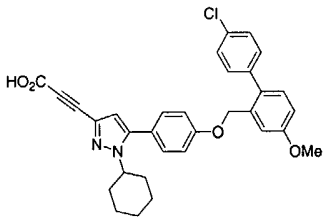
Ethyl 3-[1-cyclohexyl-5-(4-hydroxyphenyl)-1*H*-pyrazol-3-yl]-2-propynoate (7.5). A 1M solution of BCl_3 in CH_2Cl_2 (1 ml, 1.00 mmol) was added to a solution of intermediate **7.3** (86 mg, 0.207 mmol) in 2 ml of CH_2Cl_2 at -50°C, and after being stirred at -50°C for 15 min, the solution was quenched with MeOH, diluted with EtOAc, washed with H_2O, sat. $NaHCO_3$, brine, and dried (Na_2SO_4). Filtration through a 1" pad of SiO_2 and concentration provided 69 mg (100%) of **7.5**. MS (ESI) 339.3 (MH^+), 337.3 (MH^-).

Example 20



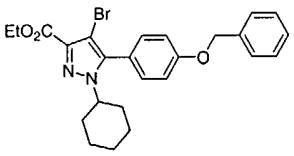
Ethyl 3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-propynoate (7.6). A mixture of **7.5** (40.9 mg, 0.120 mmol), 4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methyl bromide (44.8 mg, 0.144 mmol), and powdered K_2CO_3 (33.2 mg, 0.240 mmol) in 2 ml of CH_3CN was heated reflux for 2 h, poured into EtOAc, washed with water, brine, and dried (Na_2SO_4). The product was purified by SiO_2 chromatography (stepwise gradient: 5 to 7.5 to 10 to 12.5% EtOAc/hexanes) to afford 67 mg (98 %) of **7.6**. MS (ESI) 569.3 (MH^+).

Example 21



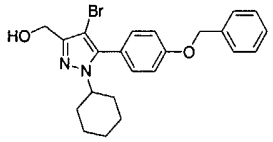
3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-propynoic acid (7.7). Ester **7.6** (55 mg, 0.097 mmol) was stirred with 1N LiOH (1 ml) in 4 ml of MeOH/THF (1:3) at rt for 24 h, concentrated, and partitioned between Et_2O and H_2O. The organic phase was extracted with 0.1 N NaOH (2X), and the combined aqueous extracts were acidified with conc. HCl, and extracted with EtOAc (3X). The combined organic extracts were washed with H_2O, brine, and dried (Na_2SO_4). The crude mixture was purified by semi-preparative HPLC (gradient elution: 70 to 100% CH_3CN/H_2O + 0.1% TFA) to give **7.7**, 52 mg (100%). HRMS (ESI) calc'd for $C_{32}H_{30}ClN_2O_4$ 514.1894, found 541.1913 (MH^+); ^1H NMR (300 MHz, $CDCl_3$) δ 7.39-7.17 (m, 8H), 7.00-6.94 (m, 3H), 6.51 (s, 1H), 4.95 (s, 2H), 4.14-4.05 (m, 1H), 3.88 (s, 3H), 2.08-1.96 (m, 2H), 1.90-1.86 (m, 4H), 1.26 (br s, 4H).

Example 22



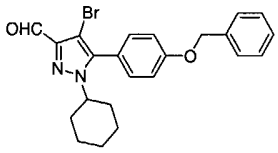
Ethyl 5-[4-(benzyloxy)phenyl]-4-bromo-1-cyclohexyl-1*H*-pyrazole-3-carboxylate (8.1). Bromine (82 μL, 1.61 mmol) was added to pyrazole **1.3** (500 mg, 1.24 mmol) in AcOH (5 ml) at 0°C and the reaction mixture was stirred at rt for 17 h. Upon concentration, the crude product was purified by SiO_2 chromatography (stepwise gradient: 20 to 25% EtOAc/ hexanes) to afford 368 mg (62%) of bromide **8.1**. MS (ESI) 483.4 (MH^+).

Intermediate 8.2



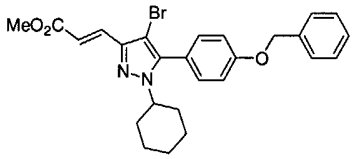
{5-[4-(benzyloxy)phenyl]-4-bromo-1-cyclohexyl-1*H*-pyrazol-3-yl}methanol (8.2). Alcohol **8.2** was prepared from **8.1** according to the procedure described above for the preparation of alcohol **2.1**. The LAH reduction **8.2** in 310 mg (98%). MS (ESI) 441.4 (MH^+).

Intermediate 8.3



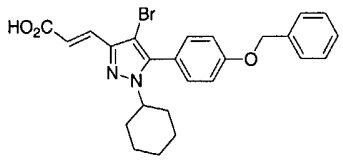
5-[4-(benzyloxy)phenyl]-4-bromo-1-cyclohexyl-1*H*-pyrazole-3-carbaldehyde (8.3). Aldehyde **8.3** was prepared from **8.2** according to the procedure described above for the preparation aldehyde **2.2**. In this example, **8.2** (295 mg, 0.668 mmol) was oxidized to yield 242 mg (82%) of **8.3**. MS (ESI) 439.3 (MH^+).

Example 23



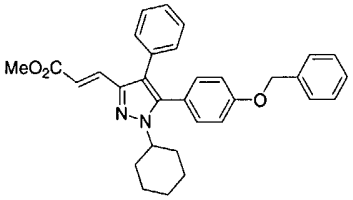
Methyl (2*E*)-3-{5-[4-(benzyloxy)phenyl]-4-bromo-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-propenoate (8.4). Methyl ester **8.4** was prepared from **8.3** according to the procedure described above for the preparation ester **2.3**. Thus, **8.3** (227 mg, 0.517 mmol) yielded 244 mg (95%) of ester **8.4**. MS (ESI) 495.4 (MH^+).

Example 24



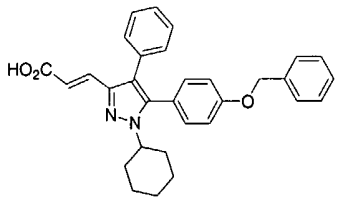
(2*E*)-3-{5-[4-(benzyloxy)phenyl]-4-bromo-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-propenoic acid (8.5). Acid **8.5** was prepared from **8.4** according to the procedure described above for the preparation acid **2.4.** Thus, **8.4** (47 mg, 0.095 mmol) was saponified to yield 45 mg (99%) of **8.5**. HRMS (ESI) calc'd for $C_{25}H_{26}BrN_2O_3$ 481.1127, found 481.1105 (MH^+); ^1H NMR (300 MHz, $CDCl_3$) δ 7.78 (d, *J* = 16.1,1H), 7.49-7.34 (m, 5H), 7.27 (d, *J* = 8.8, 2H), 7.12 (d, *J* = 8.8, 2H), 6.88 (d, *J* = 16.1, 1H), 5.14 (s, 2H), 4.04-3.96 (m, 1H), 2.00-1.83 (m, 6H), 1.26-1.24 (m, 4H).

Example 25



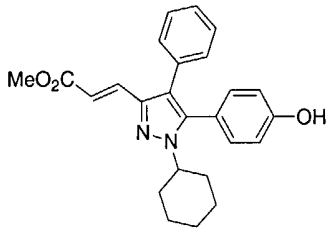
Methyl (2*E*)-3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-4-phenyl-1*H*-pyrazol-3-yl}-2-propenate (8.6). To a degassed mixture of bromide **8.4** (150 mg, 0.303 mmol), phenyl boronic (44 mg, 0.36 mmol), and tri-*o*-tolylphosphine (9.3 mg, 0.03 mmol), and $NaHCO_3$ (105 mg, 1.25 mmol) in DME/H_2O (3:1) was added $Pd(OAc)_2$ (cat.). The mixture was stirred at 90°C for 45 min, diluted with EtOAc, washed with water, brine, and dried (Na_2SO_4). Purification by silica gel chromatography (stepwise gradient: 10 to 15% EtOAc/hex) gave 115 mg (77%) of **8.6**. MS (ESI) 493.5 (MH^+).

Example 26



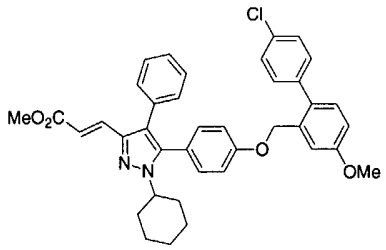
(2*E*)-3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-4-phenyl-1*H*-pyrazol-3-yl}-2-propenoic acid (8.7). Acid **8.7** was prepared from ester **8.6** according to the procedure described above for the preparation acid **2.4.** Thus, **8.6** (50 mg, 0.11 mmol) was saponified to yield 46 mg (95%) of **8.7**. HRMS (ESI) calc'd for $C_{31}H_{31}N_2O_3$, 479.2335, found 479.2343 (MH^+); ^1H NMR (300 MHz, $CDCl_3$) δ 7.72 (d, *J* = 15.7, 1H), 7.46-7.21 (m, 8H), 7.12-7.08 (m, 4H), 6.97 (d, *J* = 8.7, 2H), 6.60 (d, *J* = 15.7, 1H), 5.06 (s, 2H), 4.04-3.97 (m, 1H), 2.10-1.85 (m, 5H), 1.65 (br s, 1H), 1.33-1.22 (m, 4H).

Intermediate 8.8



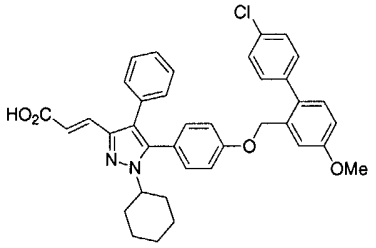
Methyl (2*E*)-3-[1-cyclohexyl-4-phenyl-5-(4-hydroxyphenyl)-1*H*-pyrazol-3-yl]-2-propenoate (8.8). Phenol **8.8** was prepared from **8.6** according to the procedure described above for the preparation phenol **3.1.** Thus, **8.6** (60 mg, 0.12 mmol) was debenzylated to yield 49 mg (100%) of **8.8**. MS (ESI) 403.3 (MH^+), 401.3 (MH^-).

Example 27



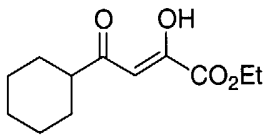
Methyl (2*E*)-3-(5-{4-[4'-chloro-4-methoxy-1,1-biphenyl)methoxy]phenyl}-1-cyclohexyl-4-phenyl-5-1*H*-pyrazol-3-yl]-2-propenoate (8.9). Ester **8.9** was prepared from **8.8** according to the procedure described above for the preparation **3.2.** Thus, **8.8** (49 mg, 0.12 mmol) was alkylated with (4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methyl bromide to afford 69.5 mg (90%) of **8.9**. MS (ESI) 633.4 (MH^+).

Example 28



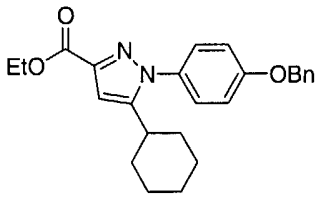
(2*E*)-3-(5-{4-[4'-chloro-4-methoxy-1,1-biphenyl)methoxy]phenyl}-1-cyclohexyl-4-phenyl-5-1*H*-pyrazol-3-yl]-2-propenoic acid (8.10). Ester **8.9** was saponified to **8.10** according to the procedure described above for the preparation acid **3.3.** Thus, **8.9** (64 mg, 0.10 mmol) was hydrolyzed to afford 53 mg (85%) of **8.10**. HRMS (ESI) calc'd for $C_{38}H_{36}ClN_2O_4$, 619.2364, found 619.2390 (MH^+); ^1H NMR (300 MHz, $CDCl_3$) δ 7.72 (d, *J* = 15.7, 1H), 7.37-7.22 (m, 8H), 7.16 (d, *J* = 2.9, 1H), 7.07 (d, *J* = 8.4, 1H), 6.96 (dd, *J* = 8.5, 2.5, 1H), 6.85 (d, *J* = 8.8, 2H), 6.60 (d, *J* = 15.7, 1H), 4.88 (s, 2H), 4.03-3.94 (m, 1H), 3.87 (s, 3H), 2.09-1.85 (m, 5H), 1.66 (br s, 1H), 1.29-1.20 (m, 4H).

Intermediate 9.1



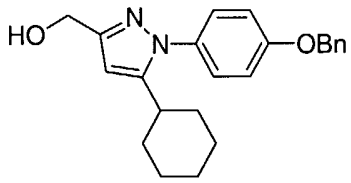
Ethyl (2Z)-4-cyclohexyl-2-hydroxy-4-oxo-2-butenoate (9.1). To a solution of cyclohexyl methyl ketone (10.4 g, 82.4 mmol) in DMF (90 ml) at rt, was added 60% NaH (3.96 g, 98.9 mmol). The mixture was stirred 45 min, cooled to 0°C, diethyl oxalate (13.4 ml, 98.9 mmol) was added and the temperature allowed to warm and stay at rt for 3 h. The reaction mixture was poured into Et_2O, extracted with H_2O (3X), and the aqueous phase was acidified with conc. HCl and extracted with EtOAc (3X). The organic extracts were washed with brine, dried (Na_2SO_4), and concentrated to afford 17.45 g (94%) of **9.1.** MS (ESI) 225.2 (MH^+).

Example 29



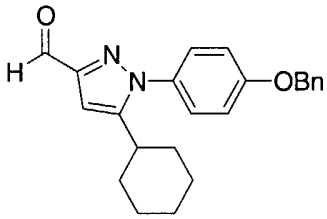
Ethyl 1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazole-3-carboxylate (9.2). According to the procedure for preparation of **1.3**, butenoate **9.1** (1 g, 4.42 mmol) and 4-benzyloxyhydrazine hydrochloride (1.33 g, 5.30 mmol) were combined and heated at reflux in EtOH (13 ml) for 1h. The mixture was filtered, concentrated, and the resultant residue purified by SiO_2 chromatography (stepwise gradient, 10 to 35% EtOAc/hexanes) to afford 845 mg (47%) of **9.2**. MS (ESI) 405.4 (MH^+).

Intermediate 9.3



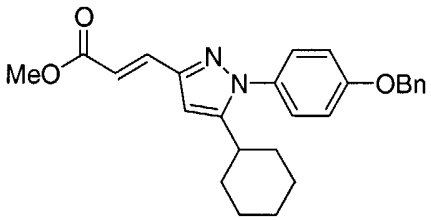
(2*E*)-3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}-2-propenoic acid (9.3). Reduction of **9.2** (1 g, 2.47 mmol) was performed according to preparation of **2.1**. Thus, 785 mg (83%) of **9.3** was obtained. MS (ESI) 363.4 (MH^+).

Intermediate 9.4



1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazole-3-carbaldehyde (9.4). According to the procedure for preparation of **2.2**, alcohol **9.3** (717 mg, 1.98 mmol) was oxidized to yield 675 mg (95%) of **9.4**. HRMS (ESI) calc'd for $C_{23}H_{25}N_2O_2$ 361.1916, found 361.1914 (MH^+).

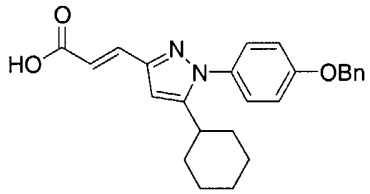
Example 30



Methyl (2*E*)-3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}-2-propenoate (9.5). According to the procedure for preparation of **2.3**, aldehyde **9.4**

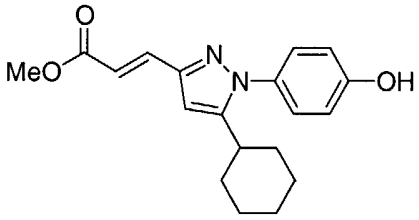
(623 mg, 1.73 mmol) was reacted with methyl (triphenylphosphoranylidene)acetate (867 mg, 2.59 mmol) to yield 536 mg (74%) of **9.5**. MS (ESI) 855.8 ($2M + Na^+$).

Example 31



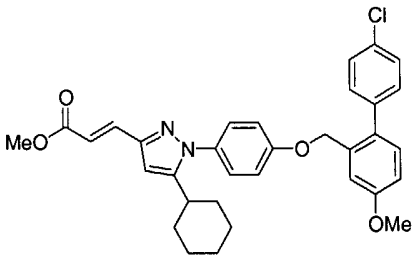
According to the procedure for preparation of **2.4**, ester **9.5** (50 mg, 0.120 mmol) was saponified to yield 42 mg (88%) of **9.6**. HRMS (ESI) calc'd for $C_{25}H_{27}N_2O_3$ 403.2022, found 403.2026 (MH^+); ^1H NMR (300 MHz, $CDCl_3$) δ 7.77 (d, J = 16.1, 1H), 7.47-7.31 (m, 7H), 7.07 (d, J = 8.8, 2H), 6.45 (s, 1H), 6.43 (d, J = 16.1, 1H), 5.13 (s, 2H), 2.61-2.53 (m, 1H), 1.86-1.68 (m, 5H), 1.39-1.19 (m, 5H).

Intermediate 9.7



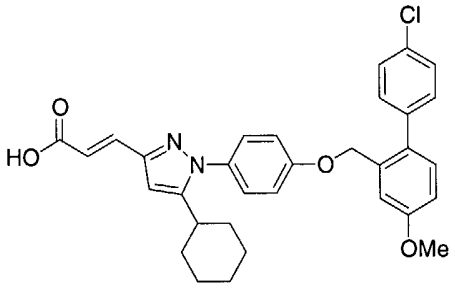
Methyl (2*E*)-3-[5-cyclohexyl-1-(4-hydroxyphenyl)-1*H*-pyrazol-3-yl]-2-propenoate (9.7). According to the procedure for preparation of **3.1**, debenzylation of **9.5** (100 mg, 0.240 mmol) with BCl_3 (1.20 mmol) to yielded 70 mg (90%) of **9.7**. MS (ESI) 653.7 ($2MH^+$); ($2M+Na^+$).

Example 32



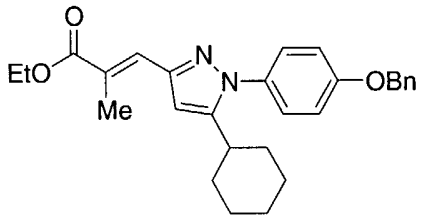
Methyl (2*E*)-3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)-2-propenoate (9.8). According to the procedure for preparation of **3.2**, phenol **9.7** (55 mg, 0.169 mmol) was alkylated with 4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methyl bromide (63.0 mg, 0.202 mmol) to yield 87 mg (93%) of **9.8**. MS (ESI) 557.5 (MH^+).

Example 33



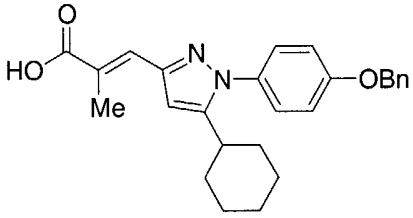
(2*E*)-3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)-2-propenoic acid (9.9). According to the procedure for the preparation of **3.3**, ester **9.8** (72 mg, 0.129 mmol) was saponified to yield 50 mg (71%) of **9.9**. HRMS (ESI) calc'd for $C_{32}H_{32}ClN_2O_4$ 543.2051, found 543.2021 (MH^+); ^1H NMR (300 MHz, $CDCl_3$) δ 7.76 (d, J = 16.1, 1H), 7.38-7.24 (m, 7H), 7.17 (d, J = 2.5, 1H), 6.99-6.93 (m, 3H), 6.44 (s, 1H), 6.43 (d, J = 15.7, 1H), 4.95 (s, 2H), 3.87 (s, 3H), 2.55-2.51 (m, 1H), 1.81-1.68 (m, 5H), 1.38-1.21 (m, 5H).

Example 34



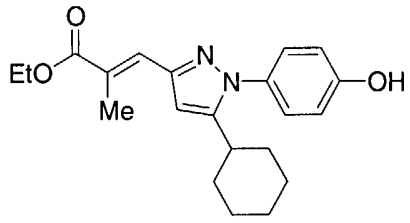
Ethyl (2*E*)-3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}-2-methyl-2-propenoate (10.1). According to the procedure for preparation of **4.1**, aldehyde **9.4** (500 mg, 1.39 mmol) was treated with (1-ethyoxycorbonylethyl)triphenylphosphonium bromide (739.6 mg, 1.67 mmol) to give 537 mg (87%) of **10.1**. MS (ESI) 445.2 (MH^+).

Example 35



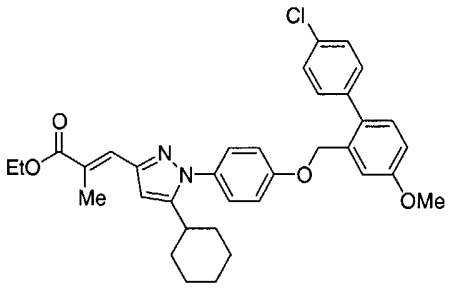
(2*E*)-3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}-2-methyl-2-propenoic acid (10.2). Ethyl ester **10.1** was subject to saponification according to the procedure for preparation of **4.2** to give 41.9 mg (90%) of **10.2**. HRMS (ESI) calc'd for $C_{26}H_{29}N_2O_3$ 417.2178, found 417.2167 (MH^+); ^1H NMR (300 MHz, $CDCl_3$) δ 7.70 (s, 1H), 7.48-7.31 (m, 7H), 7.07 (d, J = 29.1, 2H), 6.42 (s, 1H), 5.13 (s, 2H), 2.65-2.57 (m, 1H), 2.27 (s, 3H), 1.88-1.67 (m, 5H), 1.41-1.22 (m, 5H).

Intermediate 10.3



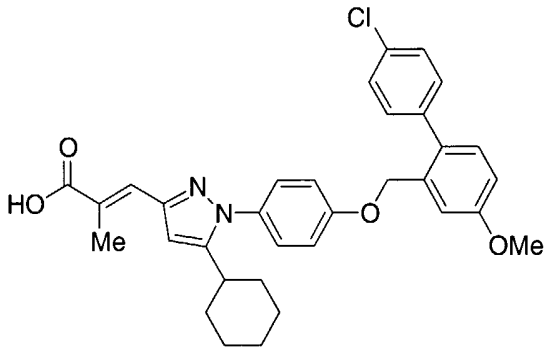
Ethyl (2*E*)-3-[5-cyclohexyl-1-(4-hydroxyphenyl)-1*H*-pyrazol-3-yl]-2-methyl-2-propenoate (10.3). According to the procedure for preparation of **4.3**, debenzylation of **10.1** (440 mg, 0.99 mmol) with 1M BCl_3 in dichloromethane (4.95 ml, 4.95 mmol) yielded 353 mg (100%) of **10.3**. MS (ESI) 355.4 (MH^+).

Example 36



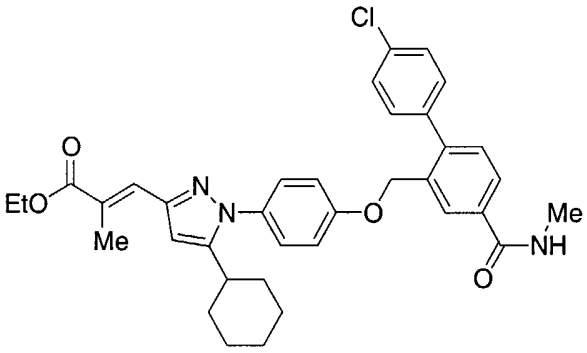
Ethyl (2*E*)-3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoate (10.4). According to the procedure for preparation of **4.4**, phenol **10.3** (50 mg, 0.14 mmol) was alkylated with 4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methyl bromide (51 mg, 0.17 mmol) to yield 78.8 mg (96%) of **10.4**. MS (ESI) 585.4 (MH^+).

Example 37



(2*E*)-3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoic acid (10.5). According to the procedure for the preparation of **4.5**, ester **10.4** (53 mg, 0.091 mmol) was saponified to yield 20 mg (39%) of **10.5**. MS (ESI) 557.4 (MH^+); ^1H NMR (300 MHz, $CDCl_3$) δ 7.76 (s, 1H), 7.39-7.24 (m, 6H), 7.18 (d, J = 2.5, 1H), 7.00-6.96 (m, 4H), 6.51 (s, 1H), 4.95 (s, 2H), 3.88 (s, 3H), 2.61-2.49 (m, 1H), 2.23 (s, 3H), 1.87-1.71 (m, 5H), 1.43-1.22 (m, 5H).

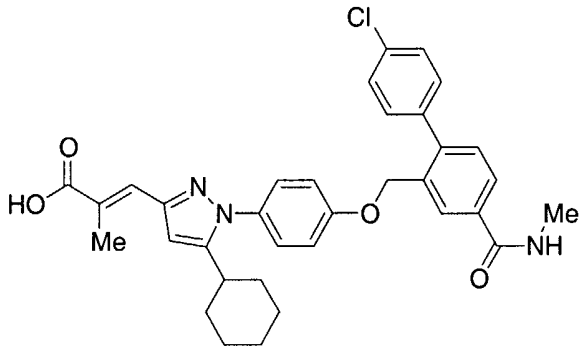
Example 38



Ethyl (2E)-1-[4-(4'-Chloro-4-methylcarbamoyl-biphenyl-2-ylmethoxy)-phenyl]-5-cyclohexyl-1H-pyrazol-3-yl]-2-methyl-2-propenoate (10.6). Phenol **10.3** (44.3 mg, 0.125 mmol) was alkylated with 2-(bromomethyl)-4'chloro-N-methyl-1,1'-biphenyl-4-carboxamide (50 mg, 0.15 mmol; *see reagent preparation*

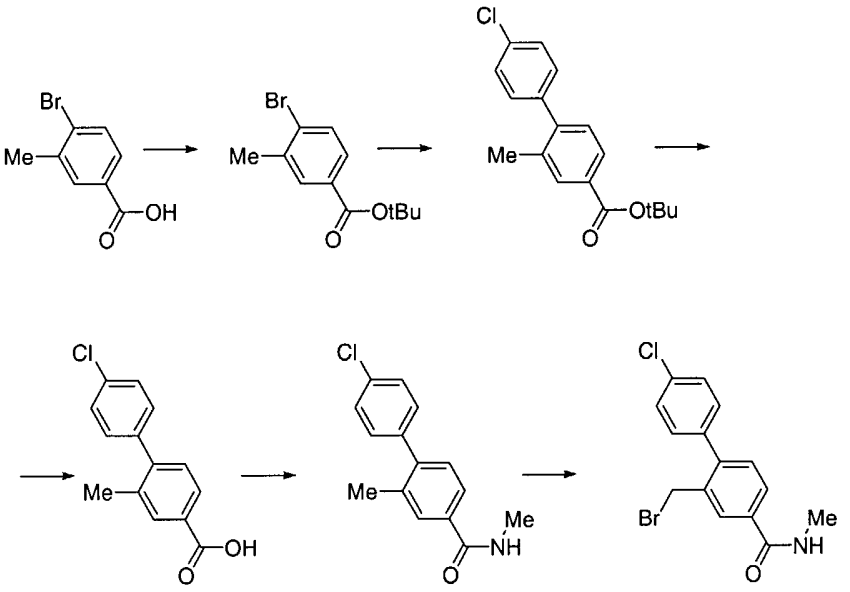
below) according the preparation of **4.4** to provide 51 mg (59%) of amide **10.6**. MS (ESI) 612.4 (MH^+).

Example 39



(2E)-1-[4-(4'-Chloro-4-methylcarbamoyl-biphenyl-2-ylmethoxy)-phenyl]-5-cyclohexyl-1H-pyrazol-3-yl]-2-methyl-2-propenoic acid (10.7). According to the procedure for preparation of **4.5**, ester **10.6** (40 mg, 0.065 mmol) was saponified to give 30.5 mg (80%) of **10.7**. HRMS (ESI) calc'd for $C_{34}H_{35}ClN_3O_4$ 584.2316, found 584.2324 (MH^+);^{1}H NMR (300 MHz, $CDCl_3$) δ 8.02 (d, *J* = 2.5, 1H), 7.82 (dd, *J* = 2.0, 7.9, 1H), 7.76 (d, *J* = 1.1, 1H), 7.43-7.28 (m, 7H), 6.95 (d, *J* = 8.8, 2H), 6.42 (s, 1H), 4.99 (s, 2H), 3.07 (d, *J* = 3.7, 3H), 2.62-2.50 (m, 1H), 2.24 (d. *J* = 1.1, 3H), 1.87-1.69 (m, 5H), 1.41-1.22 (m, 5H).

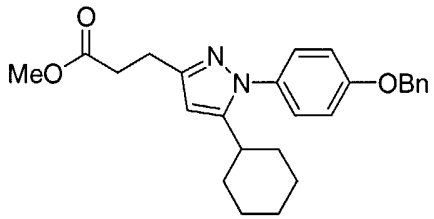
Preparation of 2-(bromomethyl)-4'chloro-N-methyl-1,1'-biphenyl-4-carboxamide



2-(bromomethyl)-4'chloro-N-methyl-1,1'-biphenyl-4-carboxamide. A suspension of 4-bromo-3-methylbenzoic acid (10 g, 46.5 mmol) was heated to 80°C and N,N-dimethylformamide di-*tert*-butyl acetal (44.6 ml, 186 mmol) was added dropwise over 30 min under N_2 atmosphere. After being stirred 1.5 h, the reaction mixture was allowed to cool, washed with water, saturated $NaHCO_3$, brine, and dried (Na_2SO_4). Concentration afforded an off-white oil 8.8 g (70%) of *tert*-butyl 4-bromo-3-methylbenzoate. To a solution of this material (3.3 g, 12.2 mmol) in 3:1 dimethoxyethane/water (55 ml) was added 4-chlorophenyl boronic acid (2.3 g, 14.6 mmol), tri-o-tolylphosphine (371 mg, 1.22 mmol), $NaHCO_3$ (4 g, 48.8 mmol). After being degassed for 20 min by a bubbling stream of N_2, palladium acetate (137 mg, 0.6 mmol) was added, and the reaction heated at 90°C for 2.5 h under N_2. The reaction mixture was cooled, and the organic layer washed with water, brine, and dried $MgSO_4$. Concentration gave a residue which was suspended in hexane and filtered to remove a precipitate which was washed well with 9:1 hexane/ethyl acetate mixture, and the combined filtrates concentrated. The residue from filtrate concentrataion was subject to Silica gel chromatography (stepwise gradient 0 – 10% EtOAc/hexane) to afford *tert*-butyl-4'-chloro-2-methyl-1,1'-biphenyl-4-carboxylate as a white solid 3.7 g (99%). MS (ESI) 303.1 (MH^+). To a solution of this material (3.7 g, 12.2 mmol) in dichloromethane (92 ml) at 0°C was added trifluoroacetate (92

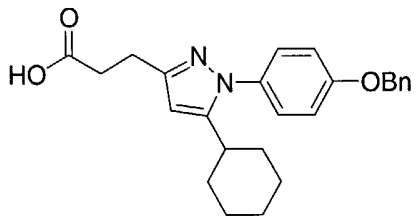
ml) dropwise over 10 min. The solution was warmed to rt and stirred 1h prior to concentration (co-evaporation with toluene, 2x50 ml) to give 4'-chloro-2-methyl-1,1'-biphenyl-4-carboxylate as a white solid 3 g (100%). MS (ESI) 247.1 (MH^+). To a solution of this material (1.5 g, 6.0 mmol), 2M methyl amine in tetrahydrofuran (6 ml, 12. Mmol), and diisopropylamine (3.2 ml, 18 mmol) in dimethylformamide (30 ml) was added benzotriazol-1-yloxyltris(dimethylamino)- phosphonium hexafluorophosphate (3.22 g, 7.3 mmol) under a N_2 atmosphere. The reaction mixture was stirred at rt for 1 h, diluted with dichloromethane (100 ml), washed with water (2x30 ml), saturated $NaHCO_3$ (2x25 ml), brine, and dried (Na_2SO_4). Concentration and silica gel chromatography (stepwise gradient 50 – 100% CH_2Cl_2/hexane) to obtain 4'-chloro-N-methyl-1,1'-biphenyl-4-carboxamide. A sample of this material was dissolved in dichloromethane (30 ml) and N-bromosuccinamide (2.14 g, 12 mmol) was added and the reaction irradiated with ultraviolet light for 4 h under reflux and N_2 atmosphere. Concentration and purification by reverse phase HPLC (C18 column; water/acetonitrile/0.05% TFA; gradient) afforded 2-(bromomethyl)-4'chloro-N-methyl-1,1'-biphenyl-4-carboxamide.

Example 40



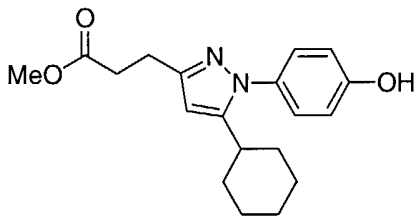
Methyl 3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}propanoate (11.1). According to the procedure for preparation **6.1,** propenoate **9.5** (149 mg, 0.358 mmol) was hydrogentaed to yield 144 mg (96%) of **11.1**. MS(ESI) 419.4 (MH^+).

Example 41



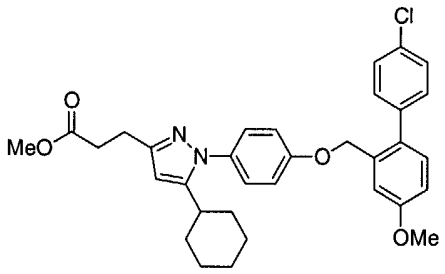
3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}propenoic acid (11.2). According to the procedure for preparation of **6.2**, ester **11.1** (44 mg, 0.105 mmol) was saponified to yield 39 mg (92%) of **11.2**. HRMS (ESI) calc'd for $C_{25}H_{29}N_2O_3$ 405.2178, found 405.2192 (MH^+); ^1H NMR (300 MHz, $CDCl_3$) δ 7.48-7.33 (m, 5H), 7.28 (d, J = 8.1, 2H), 7.04 (d, J = 8.8, 2H), 6.00 (s, 1H), 5.12 (s, 2H), 3.01-2.96 (m, 2H), 2.82-2.78 (m, 2H), 2.59-2.51 (m, 1H), 1.84-1.67 (m, 5H), 1.36-1.20 (m, 5H).

Intermediate 11.3



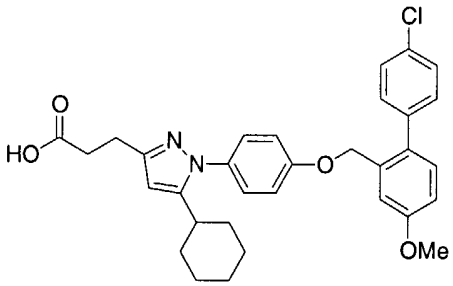
Methyl 3-[5-cyclohexyl-1-(4-hydroxyphenyl)-1*H*-pyrazol-3-yl]propanoate (11.3). According to the procedure for the preparation of **6.3**, benzylether **11.2** (124 mg, 0.296 mmol) was cleaved by catalytic hydrogenation to yield 95 mg (98%) of **11.3**. MS (ESI) 657.7 ($2MH^+$).

Example 42



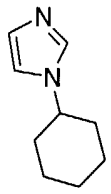
Methyl 3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)propanoate (11.4). According to the procedure for preparation of **6.4**, phenol **11.3** (83 mg, 0.253 mmol) was alkylated with 4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methyl bromide (95 mg, 0.303 mmol) to yield 133 mg (94%) of **11.4**. MS (ESI) 581.5 ($M + Na^+$).

Example 43



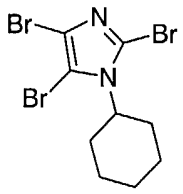
3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)propanoic acid (11.5). According to the procedure for preparation of **6.5**, ester **11.4** (108 mg, 0.193 mmol) was saponified to yield 96 mg (91%) of **11.5**. HRMS (ESI) calc'd for $C_{32}H_{34}ClN_2O_4$ 545.2207, found 545.2226 (MH^+); ^1H NMR (300 MHz, $CDCl_3$) δ 7.38-7.17 (m, 8H), 6.99-6.91 (m, 3H), 6.00 (*s*, 1H), 4.94 (s, 2H), 3.88 (s, 3H), 3.01-2.96 (m, 2H), 2.82-2.78 (m, 2H), 2.60-2.50 (m, 1H), 1.83-1.67 (m, 5H), 1.35-1.20 (m, 5H).

Intermediate 12.1



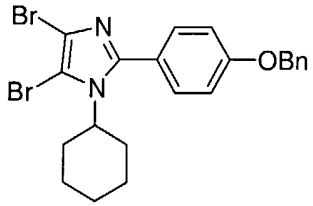
1-Cyclohexyl-1*H*-imidazole (12.1). Compound **12.1** was prepared in 44% yield by the procedure of Gridnev, A. A.; Mihaltseva, M. I. Synthesis of 1-Alkylimidazoles. *Syn. Comm.*. **1994**, *24*, 1547-1555.

Intermediate 12.2



2,4,5-tribromo-1-cyclohexyl-1*H*-imidazole (12.2.). N-bromosuccinamide (1.78 g, 9.99 mmol) dissolved in $CHCl_3$ (4 ml) at 0°C was added to a 4 ml solution of **12.1** (500 mg, 3.33 mmol) in $CHCl_3$. The mixture was stirred at rt for 17 h, filtered, concentrated, and the crude residue stirred in ether for 30 min. Filtration and concentration gave a crude product which was purified by SiO_2 chromatography (10% EtOAc/hexanes) to afford 267 mg (21%) **12.2.** MS (ESI) 385.0 (MH^+).

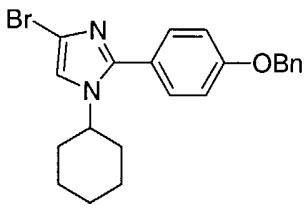
Intermediate 12.3



2-[4-(benzyloxy)phenyl]-4,5-dibromo-1-cyclohexyl-1*H*-imidazole (12.3). To a solution of **12.2** (1.99 g, 5.14 mmol) in 5:1 benzene/MeOH (24 ml) was added

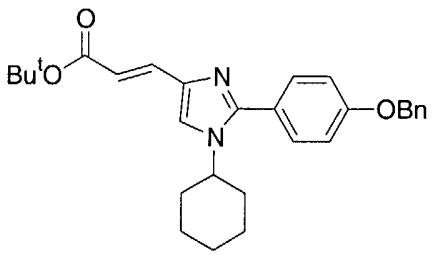
Na_2CO_3 (2M in water, 5.14 ml, 10.3 mmol) and 4-benzyloxyphenylboronic acid (1.23 g, 5.40mmol). The mixture was degassed over 10 min with N_2 and tetrakis(triphenyl-phosphine)palladium (416 mg, 0.360 mmol) added, and the reaction mixture stirred at 65°C for 12 h before being partitioned between EtOAc and H_2O. The organic phase was washed with brine, dried (Na_2SO_4), concentrated, and the crude product purified by SiO_2 chromatography (10% EtOAc/hexanes) to afford 1.96 g (78%) of **12.3**. MS (ESI) 489.2 (MH^+).

Intermediate 12.4



2-[4-(benzyloxy)phenyl]-4-bromo-1-cyclohexyl-1*H*-imidazole (12.4). To a solution of **12.3** (1 g, 2.04 mmol) in THF (11 ml) at -78°C was added 1.6 M BuLi in hexanes (1.59 ml, 2.55 mmol). The mixture was stirred at -78°C for 0.5 h, quenched with H_2O, warmed to rt, and partitioned between EtOAc and H_2O. The organic phase was washed with brine, dried (Na_2SO_4), concentrated, and the crude product purified by SiO_2 chromatography (stepwise gradient: 10 to 15 to 25% EtOAc/hexanes) to afford 723 mg (86%) of **12.4**. MS (ESI) 411.3 (MH^+).

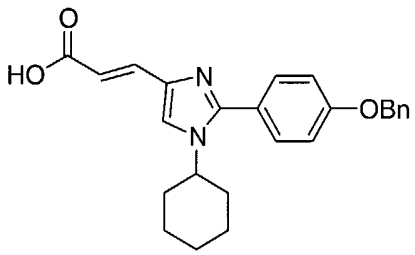
Example 44



***tert*-butyl (2*E*)-3-{2-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-imidazol-4-yl}-2-propenoate (12.5).** To a solution of **12.4** (100 mg, 0.243 mmol) in DMF (1.5

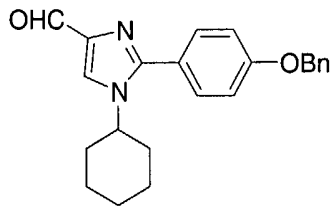
ml) was added *tert*-butyl acrylate (0.045 ml, 0.304 mmol) and tri-*o*-tolylphosphine (3.7 mg, 0.0122 mmol). After the 5 min degass with N_2, triethylamine (0.068 ml, 0.486 mmol) and $Pd(OAc)_2$ (2.7 mg, 0.0122 mmol) were added, and the reaction mixture stirred at 80°C for 17 h. Additional reagents (same molar equivalents except triethylamine (0.034 ml, 0.243 mmol) and the mixture was stirred at 100°C for an additional 3 h. Reagent addition was repeated and the mixture again stirred at 100°C for 17 h. The solution was partitioned between EtOAc and H_2O and the organic phase washed with brine, dried (Na_2SO_4), concentrated, and the crude product purified by SiO_2 chromatography (stepwise gradient: 30 to 50% Et_2O/ hexanes) to afford 67 mg (60%) of **12.5**. MS (ESI) 459.4 (MH^+).

Example 45



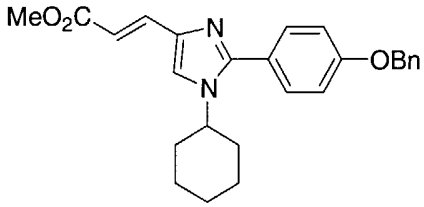
(2*E*)-3-{2-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-imidazol-4-yl}-2-propenoic acid (12.6). To a solution of **12.5** (53 mg, 0.116 mmol) in CH_2Cl_2 (2 ml) was added trifluoroacetic acid (3 ml) and the mixture was stirred for 17 h and concentrated. The crude product was purified by semi-preparative HPLC (gradient elution: 50 to 100% CH_3CN/H_2O + 0.1% TFA) to afford 43 mg (72%) of **12.6**. HRMS (ESI) calc'd for $C_{25}H_{27}N_2O_3$ 403.2022, found 403.2026 ($M + H^+$); ^1H NMR (300 MHz, $CDCl_3$) δ 7.59-7.56 (m, 3H), 7.46-7.34 (m, 6H), 7.13 (d, J = 8.4, 2H), 6.74 (d, J = 15.7, 1H), 5.12 (s, 2H), 4.20-4.11 (m, 1H), 2.07-2.03 (m, 2H), 1.95-1.89 (m, 2H), 1.75-1.71 (m, 3H), 1.28-1.25 (m, 3H).

Intermediate 12.7



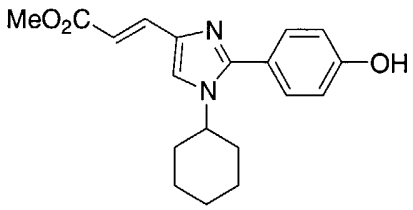
2-[4-(benzyloxy)phenyl]-4-carboxaldehyde-1-cyclohexyl-1*H*-imidazole (12.7). To a solution of **12.4** (683 mg, 1.66 mmol), in THF (7 ml) at -78°C, was added tert-BuLi (1.7 M in pentane, 2.25 ml, 3.82 mmol). The mixture was stirred at -78°C for 0.5 h, quenched with DMF (0.64 ml, 8.30 mmol), and allowed to warm to rt. Saturated NH_4Cl solution (1 ml) was added, and the resulting mixture partitioned between EtOAc and H2O. The organic phase was washed with brine, dried (Na2SO4), concentrated, and the crude product purified by silica gel chromatography (35% EtOAc/hexanes) to afford 387 mg (65%) of **12.7**. MS (ESI) 361.3 (MH^+).

Example 46



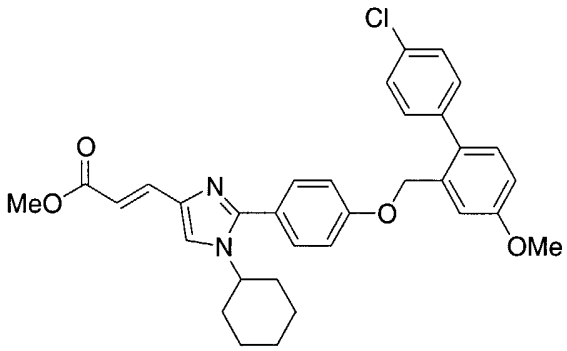
Methyl (2*E*)-3-{2-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-imidazol-4-yl}-2-propenoate (12.8). According to the procedure for preparation of **4.1**, aldehyde **12.7** (150 mg, 0.416 mmol) was reacted with methyl (triphenylphosphoranylidene)acetate (209 mg, 0.624 mmol) to yield 128 mg (74%) of **12.8**. MS (ESI) 417.3 (MH^+).

Intermediate 12.9



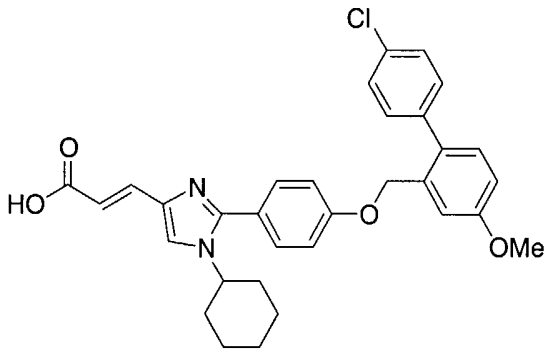
Methyl (2*E*)-3-{2-[4-(hydroxy)phenyl]-1-cyclohexyl-1*H*-imidazol-4-yl}-2-methyl-2-propenoate (12.9). According to the procedure for preparation of **4.3**, ester **12.8** (117 mg, 0.281 mmol) was reacted with BCl3 (1.40 mmol) to yield 69 mg (75%) of **12.9**. MS (ESI) 327.3 (MH^+).

Example 47



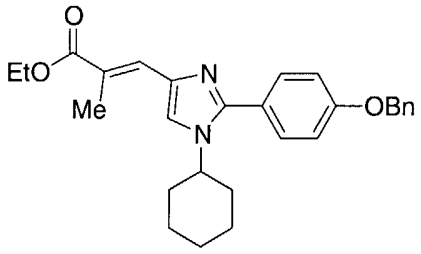
Methyl (2E)-3-(2-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-propenoate (12.10). According to the procedure for preparation of **4.4**, phenol **12.9** (60 mg, 0.184 mmol) was alkylated with (4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methyl bromide (63 mg, 0.202 mmol), to yield 75 mg (73%) of **12.10**. MS (ESI) 557.4 (MH^+).

Example 48



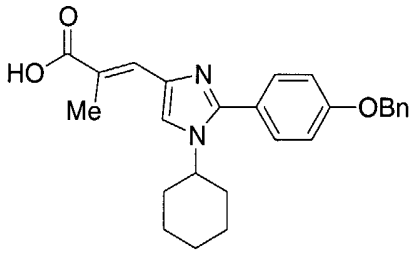
(2E)-3-(2-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-propenoic acid (12.11). According to the procedure for preparation of **4.5**, ester **12.10** (60 mg, 0.108 mmol) was saponified to yield 56 mg (79%) of **12.11**. HRMS (ESI) calc'd for $C_{32}H_{32}ClN_2O_4$ 543.2051, found 543.2005 (M + H+); 1H NMR (300 MHz, CDCl3) δ 7.56-7.53 (m, 3H), 7.43-7.24 (m, 6H), 7.14 (d, J = 3.0, 1H), 7.03-6.95 (m, 3H), 6.74 (d, J = 16.1, 1H), 4.95 (s, 2H), 4.21-4.11 (m, 1H), 3.86 (s, 3H), 2.07-2.03 (m, 2H), 1.89-1.86 (m, 2H), 1.80-1.65 (m, 3H), 1.29-1.23 (m, 3H).

Example 49



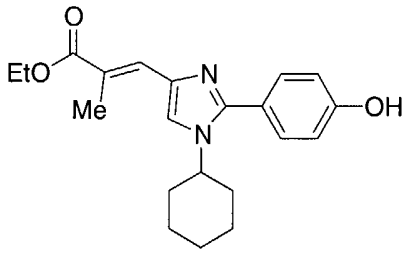
Ethyl (2*E*)-3-{2-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-imidazol-4-yl}-2-methyl-2-propenoate (13.1). According to the procedure for preparation of **4.1**, aldehyde **12.7** (225 mg, 0.624 mmol) was reacted with (1-ethoxycarbonylethyl)triphenylphosponium bromide (346 mg, 0.780 mmol) to yield 234 mg (85%) of **13.1**. MS (ESI) 445.5 (MH+).

Example 50



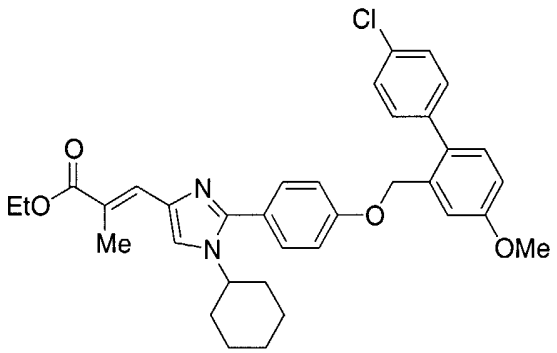
(2E)-3-{2-[4-(benzyloxy)phenyl]-1-cyclohexyl-1H-imidazol-4-yl}-2-methyl-2-propenoic acid (13.2.). According to the procedure for preparation of **4.2**, ester **13.1** (50 mg, 0.112 mmol) was saponified to yield 38 mg (64%) of **13.2**. HRMS (ESI) calc'd for $C_{26}H_{29}N_2O_3$ 417.2178, found 417.2180 (MH^+); 1H NMR (300 MHz, CDCl3) δ 7.60-7.57 (m, 3H), 7.46-7.35 (m, 6H), 7.14 (d, J = 8.4, 2H), 5.12 (s, 2H), 4.20-4.16 (m, 1H), 2.10-2.05 (m, 5H), 1.91-1.74 (m, 5H), 1.31-1.29 (m, 3H).

Intermediate 13.3



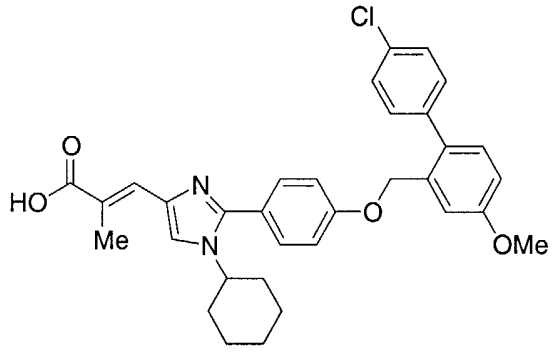
Ethyl (2*E*)-3-{2-[4-(hydroxy)phenyl]-1-cyclohexyl-1*H*-imidazol-4-yl}-2-methyl-2-propenoate (13.3). According to the procedure for preparation of **4.3**, ester **13.1** (167 mg, 0.376 mmol) was treated with BCl_3 (1.88 mmol) to yield 80 mg (60%) of **13.3**. MS (ESI) 355.3 (MH^+).

Example 51



Ethyl (2E)-3-(2-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-methyl-2-propenoate (13.4). According to the procedure for preparation of **4.4**, phenol **13.3** (73 mg, 0.206 mmol) was alkylated with (4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methyl bromide (71 mg, 0.227 mmol), to yield 59 mg (49%) of **13.4**. MS (ESI) 585.4 (MH^+).

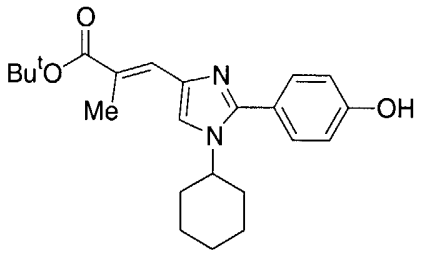
Example 52



(2E)-3-(2-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-methyl-2-propenoic acid (13.5). According to the procedure for preparation of **4.5**, ester **13.4** (55 mg, 0.0940 mmol) was saponified to yield 42 mg (67%) of **13.5**. HRMS (ESI) calc'd for $C_{33}H_{34}ClN_2O_4$ 557.2207, found 557.2216 (MH^+); 1H NMR (300 MHz, CDCl3) δ 7.57-7.54 (m, 3H), 7.42-7.24 (m, 6H), 7.15 (d, J = 2.5, 1H), 7.03 (d, J = 8.8, 2H), 6.97 (d,d J = 8.5, 2.6, 1H), 4.95 (s,

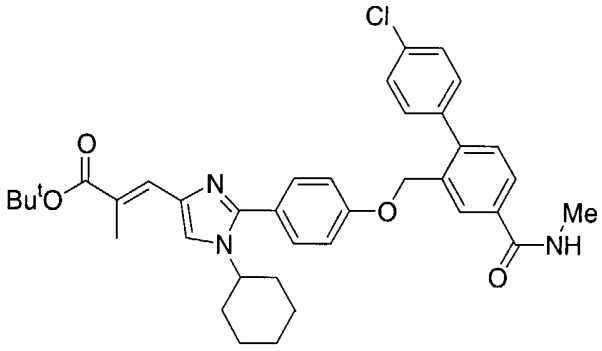
2H), 4.23-4.11 (m, 1H), 3.87 (s, 3H), 2.11-2.03 (m, 5H), 1.95-1.93 (m, 2H), 1.80-1.76 (m, 3H), 1.40-1.21 (m, 3H).

Intermediate 13.6



t-Butyl (2*E*)-3-{2-[4-(hydroxy)phenyl]-1-cyclohexyl-1*H*-imidazol-4-yl}-2-methyl-2-propenoate (13.6). According to the procedure for preparation of **4.1**, aldehyde **12.7** (300 mg, 0.83 mmol) was reacted with (1-t-butoxycarbonylethyl)-triphenylphosponium bromide (350 mg, 0.88 mmol), and the resulting product was dissolved in ethanol (2 ml) and 10% Pd/C (400 mg) added followed by addition of 1,4-cyclhexadiene (excess 0.8 g). The reaction mixture was stirred at 45°C for10 h, filtered, and concentrated to yield 190 mg (60%) of **13.6**. MS (ESI) 383.27 (MH^+).

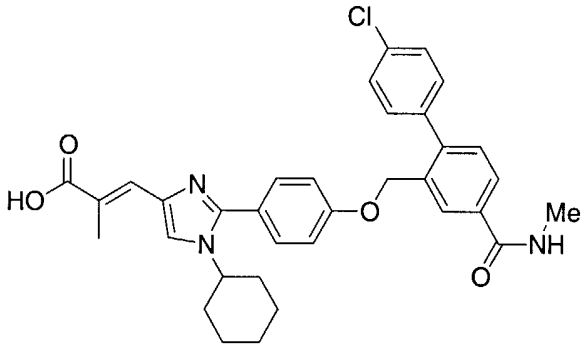
Example 53



Butoxy^t (2E)-3-(2-{4-[(4'-chloro-4-N-methylcarbamoyl-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-methyl-2-propenoate. Ester **13.6** (20 mg, 0.052 mmol), 2-(hydroxylmethyl)-4'chloro-N-methyl-1,1'-biphenyl-4-caroxamide (14.4 mg, 0.52 mmol), and triphenylphosphene (16.5 mg,

0.063 mmol) were taken up in THF (0.25 ml) and cooled to 0°C under N_2 and diisopropylazo-dicarboxylate (12 mg, 0.06 mmol), dissolved in an equal volume of the same solvent, was added dropwise. The reaction was allowed to stand at rt for 18 h and an addition equivalent of each reagent was added to the reaction mixture. Water (3 drops) was added, concentrate to remove volatiles, and subject to reverse phase HPLC as above to yield 26 mg (66%) of **13.7**. MS (ESI) 640.19 (MH^+).

Example 54

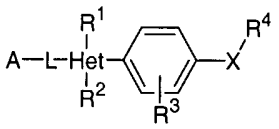


(2E)-3-(2-{4-[(4'-chloro-4-N-methylcarbamoyl-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-methyl-2-propenoic acid. According to the procedure for preparation of **12.6**, ester **13.7** (20 mg, 0.031 mmol) was cleaved to acid to give 22.5 mg (100%) of **13.8** as TFA salt. HRMS (ESI) calc'd for C34H34ClN3O4 584.2316, found 584.2319 (MH^+); 1H NMR (300 MHz, CD_3OD) δ 8.05-8.10 (m, 2H), 7.87-7.90 (m, 1H), 7.60 (d, J = 8.8, 2H), 7.42-7.46 (m, 6H), 7.17 (d, J = 8.8, 2H), 5.12 (s, 2H), 4.24-4.28 (m, 1H), 3.30 (s, 3H), 2.94 (s, 3H), 1.91-2.06 (m, 6H), 1.27-1.37 (m, 4H).

CLAIMS

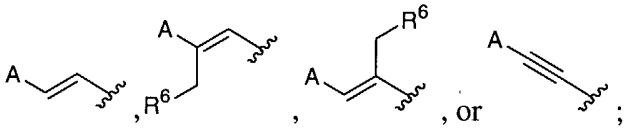
We claim:

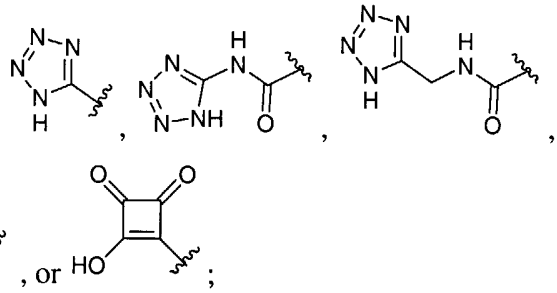
1. A compound of Formula (I)



I

where:

A-L is $A(CH_2)_{0-6}$–,  ;

A is CO_2R^5, $CONSO_2R^5$, SO_2NCOR^5,  ;

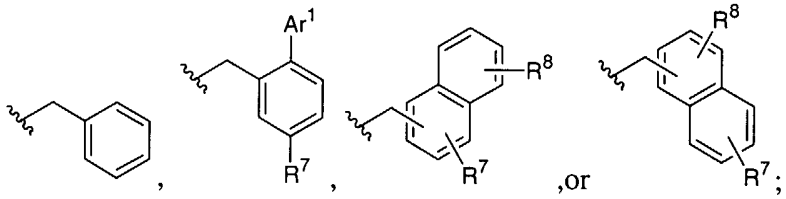
Het is pyrazole, imidazole, oxazole, triazole, thiazole, pyrrole, furan, or thiophene;

X is O, S, NR^5, or CH_2;

R^1 is hydrogen, halogen, C_{1-6}alkyl, trifluoromethyl, or phenyl;

R^2 is C_{3-7}cycloalkyl or C_{5-12} bridged bicycloalkyl;

R^3 is hydrogen, halogen, C_{1-6}alkyl, or C_{1-6}alkoxy;

R^4 is  ;

R^5 is hydrogen or C_{1-6}alkyl;

R^6 is hydrogen, methyl, or OR^5;

R^7 is C_{1-6}alkoxy, cyano, trifluoromethyl, $-CO_2R^5$, $-CONR^9R^{10}$, SO_2R^5, or $SO_2NR^9R^{10}$;

R^8 is hydrogen, halogen, C_{1-6}alkyl, C_{1-6}alkoxy, cyano, trifluoromethyl, aceto, CO_2R^5, or $CONR^9R^{10}$;

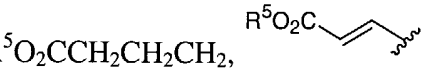
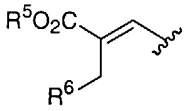
R^9 and R^{10} are independently hydrogen, C_{1-6}alkyl, $-CH_2CH_2OH$; or

NR^9R^{10} taken together form pyrrolidine, piperidine, 4-hydroxypiperidine, piperazine, 4-methylpiperazine, morpholine, or thiomorpholine; and

Ar^1 is thiophene or phenyl substituted with 0-3 substituents selected from halogen, C_{1-6}alkyl, C_{1-6}alkoxy, cyano, trifluoromethyl, aceto, CO_2R^5, and $CONR^9R^{10}$;

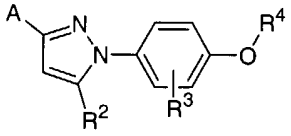
or a pharmaceutically acceptable salt or solvate of these compounds.

2. A compound of claim 1 where X is O.

3. A compound of claim 2 where A-L is $R^5O_2CCH_2CH_2CH_2$,  , or  .

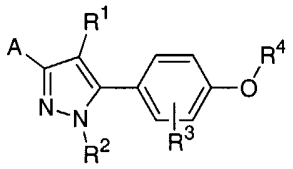
4. A compound of claim 2 where Het is pyrazole, imidazole, oxazole, or triazole.

5. A compound of claim 4 where Formula (I) is Formula (Ia).



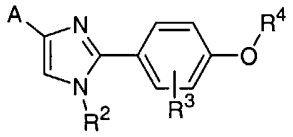
(Ia)

6. A compound of claim 4 where Formula (I) is Formula (Ib).



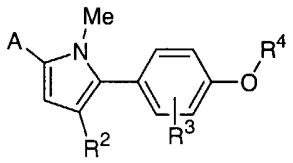
(Ib)

7. A compound of claim 4 where Formula (I) is Formula (Ic).



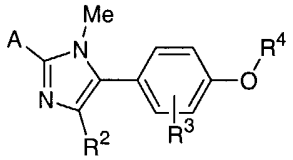
(Ic)

8. A compound of claim 4 where Formula (I) is Formula (Id).



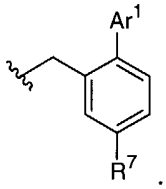
(Id)

9. A compound of claim 4 where Formula (I) is Formula (Ie).



(Ie)

10. A compound of claim 2 where R^2 is cyclohexyl.

11. A compound of claim 2 where R^4 is  .

12. A compound of claim 2 selected from the group consisting of

(1) ethyl 1-cyclohexyl-5-(4-benzyloxyphenyl)-1*H*-pyrazole-3-carboxylate;

(2) methyl (2*E*)-3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-propenoate;

(3) (2*E*)-3-[1-cyclohexyl-5-(4-benzyloxyphenyl)-1*H*-pyrazol-3-yl]-2-propenoic acid;

(4) methyl (2E)-3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-pyrazol-3-yl)-2-propenoate;

(5) (2*E*)-3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-propenoic acid;

(6) ethyl (2*E*)-3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-methyl-2-propenoate;

(7) (2*E*)-3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-methyl-2-propenoic acid;

(8) ethyl (2*E*)-3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoate;

(9) (2*E*)-3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoic acid;

(10) ethyl (2*E*)-3-(5-{4-[(*t*-butyl-2-bromo-5-phenylcarboxylate)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoate;

(11) ethyl (2*E*)-3-(5-{4-[(4'-chloro-4-t-butoxycarbonyl-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoate;

(12) ethyl (2*E*)-3-(5-{4-[(4'-Chloro-4-N-methylcarbamoyl-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoate;

(13) (2*E*)-3-(5-{4-[(4'-Chloro-4-N-methylcarbamoyl-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoic acid;

(14) methyl 3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}propanoate;

(15) 3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}propanoic acid;

(16) methyl 3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)propanoate;

(17) 3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)propanoic acid;

(18) ethyl 3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-propynoate;

(19) 3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-propynoic acid;

(20) ethyl 3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-propynoate;

(21) 3-(5-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1*H*-pyrazol-3-yl)-2-propynoic acid;

(22) ethyl 5-[4-(benzyloxy)phenyl]-4-bromo-1-cyclohexyl-1*H*-pyrazole-3-carboxylate;

(23) methyl (2*E*)-3-{5-[4-(benzyloxy)phenyl]-4-bromo-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-propenoate;

(24) (2*E*)-3-{5-[4-(benzyloxy)phenyl]-4-bromo-1-cyclohexyl-1*H*-pyrazol-3-yl}-2-propenoic acid;

(25) methyl (2*E*)-3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-4-phenyl-1*H*-pyrazol-3-yl}-2-propenate;

(26) (2*E*)-3-{5-[4-(benzyloxy)phenyl]-1-cyclohexyl-4-phenyl-1*H*-pyrazol-3-yl}-2-propenoic acid;

(27) methyl (2*E*)-3-(5-{4-[4'-chloro-4-methoxy-1,1-biphenyl)methoxy]phenyl}-1-cyclohexyl-4-phenyl-5-1*H*-pyrazol-3-yl]-2-propenoate;

(28) (2*E*)-3-(5-{4-[4'-chloro-4-methoxy-1,1-biphenyl)methoxy]phenyl}-1-cyclohexyl-4-phenyl-5-1*H*-pyrazol-3-yl]-2-propenoic acid;

(29) ethyl 1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazole-3-carboxylate;

(30) methyl (2*E*)-3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}-2-propenoate;

(31) (2*E*)-3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}-2-propenoic acid;

(32) methyl (2*E*)-3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)-2-propenoate;

(33) (2*E*)-3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)-2-propenoic acid;

(34) ethyl (2*E*)-3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}-2-methyl-2-propenoate;

(35) (2*E*)-3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}-2-methyl-2-propenoic acid;

(36) ethyl (2*E*)-3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoate;

(37) (2*E*)-3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)-2-methyl-2-propenoic acid;

(38) ethyl (2E)-1-[4-(4'-Chloro-4-methylcarbamoyl-biphenyl-2-ylmethoxy)-phenyl]-5-cyclohexyl-1H-pyrazol-3-yl]-2-methyl-2-propenoate;

(39) (2E)-1-[4-(4'-chloro-4-methylcarbamoyl-biphenyl-2-ylmethoxy)-phenyl]-5-cyclohexyl-1H-pyrazol-3-yl]-2-methyl-2-propenoic acid;

(40) methyl 3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}propanoate;

(41) 3-{1-[4-(benzyloxy)phenyl]-5-cyclohexyl-1*H*-pyrazol-3-yl}propenoic acid;

(42) methyl 3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)propanoate;

(43) 3-(1-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-5-cyclohexyl-1*H*-pyrazol-3-yl)propanoic acid;

(44) *tert*-butyl (2*E*)-3-{2-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-imidazol-4-yl}-2-propenoate;

(45) (2*E*)-3-{2-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-imidazol-4-yl}-2-propenoic acid;

(46) methyl (2*E*)-3-{2-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-imidazol-4-yl}-2-propenoate;

(47) methyl (2E)-3-(2-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-propenoate;

(48) (2E)-3-(2-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-propenoic acid;

(49) ethyl (2*E*)-3-{2-[4-(benzyloxy)phenyl]-1-cyclohexyl-1*H*-imidazol-4-yl}-2-methyl-2-propenoate;

(50) (2E)-3-{2-[4-(benzyloxy)phenyl]-1-cyclohexyl-1H-imidazol-4-yl}-2-methyl-2-propenoic acid;

(51) ethyl (2E)-3-(2-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-methyl-2-propenoate;

(52) (2E)-3-(2-{4-[(4'-chloro-4-methoxy-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-methyl-2-propenoic acid;

(53) t-Butoxy (2E)-3-(2-{4-[(4'-chloro-4-N-methylcarbamoyl-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-methyl-2-propenoate; and

(54) (2E)-3-(2-{4-[(4'-chloro-4-N-methylcarbamoyl-1,1'-biphenyl-2-yl)methoxy]phenyl}-1-cyclohexyl-1H-imidazol-4-yl)-2-methyl-2-propenoic acid.

13. A pharmaceutical composition comprising a therapeutic amount of a compound of claim 1, or its pharmaceutically acceptable salt or solvate, and a pharmaceutically acceptable carrier.

14. The pharmaceutical composition of claim 13 further comprising a therapeutic amount of

(a) a replicase inhibitor,
(b) a metalloprotease inhibitor,
(c) a NS3 protease inhibitor,
(d) a NS3 helicase inhibitor,
(e) a NS5A inhibitor,
(f) a NS5B polymerase inhibitor,
(g) or a combination of the above.

15. A method for inhibiting hepatitis C NS5B RNA-dependent RNA polymerase in a patient in need of such treatment comprising administering a therapeutic amount of a compound of claim 1 to a patient in need of such treatment.

16. The method of claim 15 further comprising co-administering a therapeutic amount of

(a) a replicase inhibitor,
(b) a metalloprotease inhibitor,
(c) a NS3 protease inhibitor,
(d) a NS3 helicase inhibitor,
(e) a NS5A inhibitor,
(f) a NS5B polymerase inhibitor,
(g) or a combination of the above.

17. A method for treating or preventing a hepatitis C viral infection in a patient in need of such treatment comprising administering a therapeutic amount of a compound of claim 1 to a patient in need of such treatment.

18. The method of claim 17 further comprising co-administering a therapeutic amount of

(a) a replicase inhibitor,

(b) a metalloprotease inhibitor,

(c) a NS3 protease inhibitor,

(d) a NS3 helicase inhibitor,

(e) a NS5A inhibitor,

(f) a NS5B polymerase inhibitor,

(g) or a combination of the above.

19. A method for treating or preventing hepatitis C in a patient in need of such treatment comprising administering a therapeutic amount of a compound of claim 1 to a patient in need of such treatment.

20. The method of claim 19 further comprising co-administering a therapeutic amount of

(a) a replicase inhibitor,

(b) a metalloprotease inhibitor,

(c) a NS3 protease inhibitor,

(d) a NS3 helicase inhibitor,

(e) a NS5A inhibitor,

(f) a NS5B polymerase inhibitor,

(g) or a combination of the above.