However, the derivatives provide a significantly smaller increase in the RON of a fuel than is provided by NMA at similar treat rates.

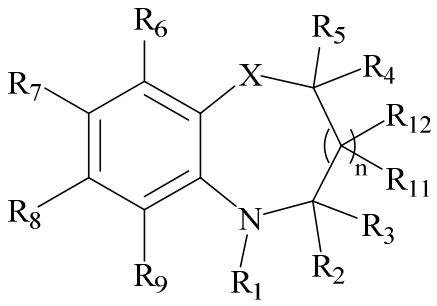
Accordingly, there remains a need for additives for a fuel for a spark-ignition internal combustion engine that are able to achieve anti-knock effects, *e.g.* at least comparable anti-knock effects to NMA, while mitigating at least some of the problems highlighted above.

Summary of the Invention

Surprisingly, it has now been found that an additive having a chemical structure comprising a 6-membered aromatic ring sharing two adjacent aromatic carbon atoms with a 6- or 7-membered saturated heterocyclic ring, the 6- or 7-membered saturated heterocyclic ring comprising a nitrogen atom directly bonded to one of the shared carbon atoms to form a secondary amine and an atom selected from oxygen or nitrogen directly bonded to the other shared carbon atom, the remaining atoms in the 6- or 7-membered heterocyclic ring being carbon, provides a substantial increase to the octane number, particularly the RON, of a fuel for a spark-ignition internal combustion engine. Such octane-boosting additives are also predicted to exhibit lower toxicity that NMA. Reduced toxicity would enable additive compositions, containers and kits comprising the octane-boosting additives to provide octane-boosting benefits, whilst being easily stored, transported, used and disposed of.

Accordingly, in one aspect, the present disclosure provides an additive composition for use in a fuel for a spark-ignition internal combustion engine, the additive composition comprising an octane-boosting additive having a chemical structure comprising a 6-membered aromatic ring sharing two adjacent aromatic carbon atoms with a 6- or 7-membered saturated heterocyclic ring, the 6- or 7-membered saturated heterocyclic ring comprising a nitrogen atom directly bonded to one of the shared carbon atoms to form a secondary amine and an atom selected from oxygen or nitrogen directly bonded to the other shared carbon atom, the remaining atoms in the 6- or 7-membered heterocyclic ring being carbon, and one or more further fuel additives.

In another aspect, there is provided an additive composition comprising an octane-boosting additive and a detergent, wherein the octane-boosting additive has the formula:



where: R1 is hydrogen;

R2, R3, R4, R5, R11 and R12 are each independently selected from hydrogen, alkyl, alkoxy, alkoxy-alkyl, secondary amine and tertiary amine groups;

R6, R7, R8 and R9 are each independently selected from hydrogen, alkyl, alkoxy, alkoxy-alkyl, secondary amine and tertiary amine groups;

X is selected from -O- or -NR10-, where R10 is selected from hydrogen and alkyl groups; and

n is 0 or 1;

wherein at least one of R2, R3, R4, R5¸R6, R7, R8, R9, R11, and R12 is selected from a group other than hydrogen.

In another aspect, the present disclosure provides a container comprising:

(i) an octane-boosting additive described herein; and

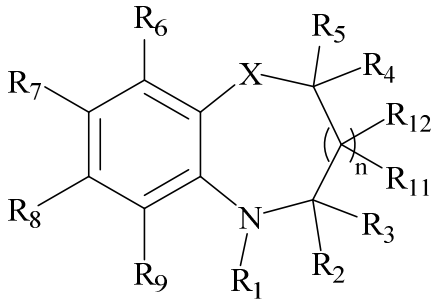
(ii) means configured to introduce the octane-boosting additive into a fuel system.

In another aspect, there is provided a container comprising an octane-boosting additive in an amount which is greater than 100mL, wherein the octane-boosting additive has a structure as defined herein.

In another aspect, the present disclosure further provides a container comprising an octane-boosting

Claims:

1. An additive composition comprising an octane-boosting additive and a detergent, wherein the octane-boosting additive has the formula:



where: R_1 is hydrogen;

R_2, R_3, R_4, R_5, R_{11} and R_{12} are each independently selected from hydrogen, alkyl, alkoxy, alkoxy-alkyl, secondary amine and tertiary amine groups;

R_6, R_7, R_8 and R_9 are each independently selected from hydrogen, alkyl, alkoxy, alkoxy-alkyl, secondary amine and tertiary amine groups;

X is selected from -O- or -NR_{10}-, where R_{10} is selected from hydrogen and alkyl groups; and

n is 0 or 1;

wherein at least one of R_2, R_3, R_4, R_5,R_6, R_7, R_8, R_9, R_{11}, and R_{12} is selected from a group other than hydrogen.

2. An additive composition according to claim 1,wherein R_2, R_3, R_4, R_5, R_{11} and R_{12} are each independently selected from hydrogen and alkyl groups, preferably from hydrogen, methyl, ethyl, propyl and butyl groups, more preferably from hydrogen, methyl and ethyl, and even more preferably from hydrogen and methyl.

3. An additive composition according to claim 1 or claim 2, wherein R_6, R_7, R_8 and R_9 are each independently selected from hydrogen, alkyl and alkoxy groups, preferably from hydrogen, methyl, ethyl, propyl, butyl, methoxy, ethoxy and propoxy groups, more preferably from hydrogen, methyl, ethyl and methoxy, and even more preferably from hydrogen, methyl and methoxy.

4. An additive composition according to any preceding claim, wherein no more than five, preferably no more than three, and more preferably no more than two, of R_2, R_3, R_4, R_5, R_6, R_7, R_8, R_9, R_{11} and R_{12} are selected from a group other than hydrogen.

5. An additive composition according to any preceding claim, wherein at least one of R_2 and R_3 is hydrogen, and preferably wherein R_2 and R_3 are hydrogen.

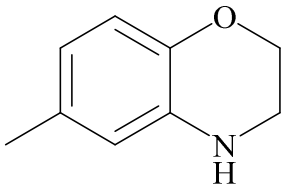
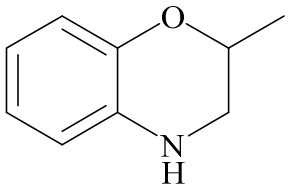
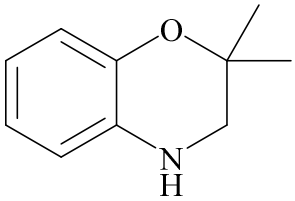
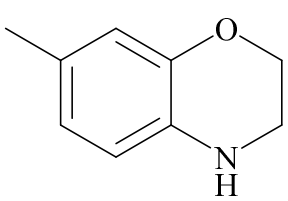
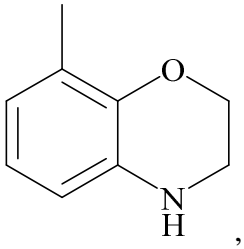
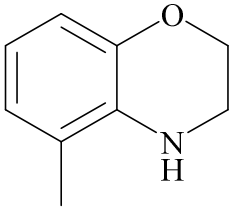
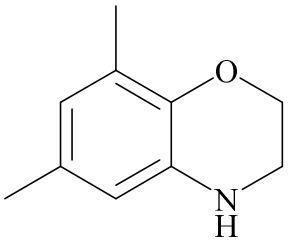
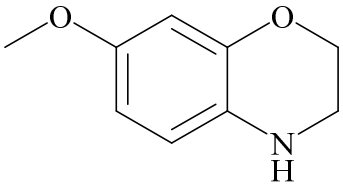
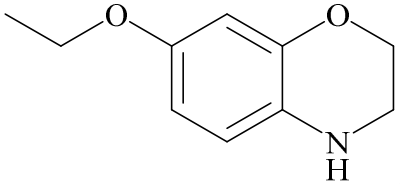
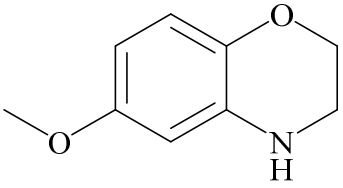
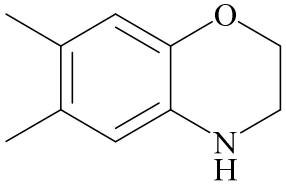
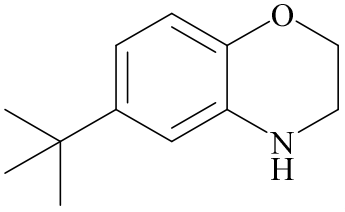
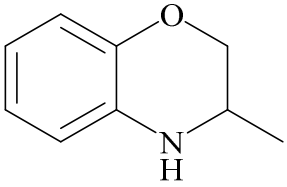
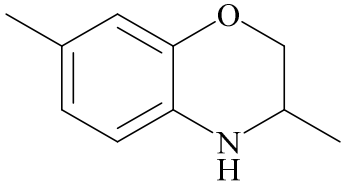
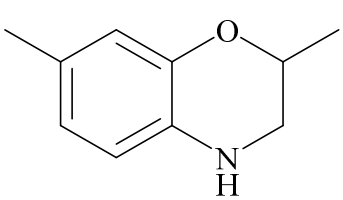
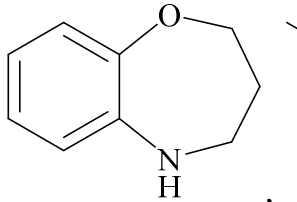
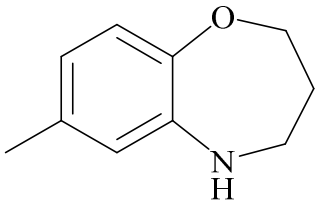
6. An additive composition according to any preceding claim, wherein at least one of R_4, R_5, R_7 and R_8 is selected from methyl, ethyl, propyl and butyl groups and the remainder of R_2, R_3, R_4, R_5, R_6, R_7, R_8, R_9, R_{11} and R_{12} are hydrogen, and preferably wherein at least one of R_7 and R_8 are selected from methyl, ethyl, propyl and butyl groups and the remainder of R_2, R_3, R_4, R_5, R_6, R_7, R_8, R_9, R_{11} and R_{12} are hydrogen.

7. An additive composition according to claim 6, wherein at least one of R_4, R_5, R_7 and R_8 is a methyl group and the remainder of R_2, R_3, R_4, R_5, R_6, R_7, R_8, R_9, R_{11} and R_{12} are hydrogen, and preferably wherein at least one of R_7 and R_8 is a methyl group and the remainder of R_2, R_3, R_4, R_5, R_6, R_7, R_8, R_9, R_{11} and R_{12} are hydrogen.

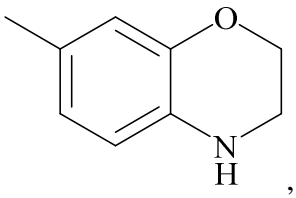
8. An additive composition according to any preceding claim, wherein X is -O- or -NR_{10}-, where R_{10} is selected from hydrogen, methyl, ethyl, propyl and butyl groups, preferably from hydrogen, methyl and ethyl groups, and even more preferably is hydrogen, and preferably wherein X is -O-.

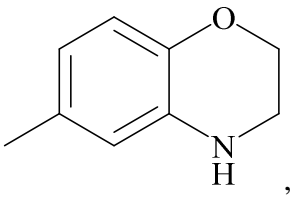
9. An additive composition according to any preceding claim, wherein n is 0.

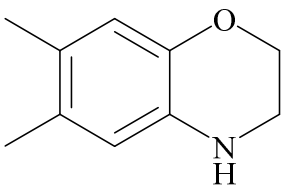
10. An additive composition according to any preceding claim, wherein the additive is selected from:


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and preferably from:



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11. An additive composition according to any preceding claim, wherein the octane-boosting additive is present in the additive composition in an amount of at least 10 % by weight, preferably from 15 % to 95 % by weight, more preferably from 20 % to 80 % by weight, and still more preferably from 30 % to 80 % by weight.

12. A container comprising:
(i) an octane-boosting additive as defined in any of claims 1-11; and
(ii) means configured to introduce the octane-boosting additive into a fuel system.

13. A container according to claim 12, wherein the means are configured to couple the container to the fuel system.

14. A container according to claim 12 or claim 13, wherein the means comprise a funnel, a spout or an injector.

15. A container according to any of claims 12 to 14, wherein the fuel system comprises an engine or a fuel tanker.

16. A container comprising an octane-boosting additive in an amount which is greater than 100 mL, wherein the octane-boosting additive has a structure as defined in any of claims 1 to 11.

17. The container of claim 16, wherein the container comprises the octane-boosting additive in an amount which is:

(a) suitable for treating a fuel in a fuel tank or a fuel tanker at a rate of 0.1 % to 10 %, more preferably from 0.2 % to 5 %, still more preferably from 0.25 % to 2 %, and even more preferably still from 0.3 % to 1 % weight additive / weight base fuel;

(b) suitable for increasing the octane number of a fuel in a fuel tank or a fuel tanker by at least 0.5, preferably at least 1, more preferably at least 2, and still more preferably at least 2.5; and/or

(c) greater than 150 ml, and more preferably greater than 200 ml.