GB 2 308 849 discloses dihydro benzoxazine derivatives for use as anti-knock agents. However, the derivatives provide a significantly smaller increase in the RON of a fuel than is provided by NMA at similar treat rates.

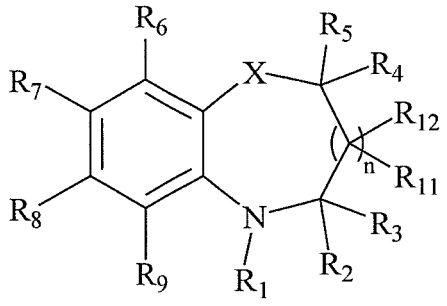
Accordingly, there remains a need for additives for a fuel for a spark-ignition internal combustion engine that are able to achieve anti-knock effects, *e.g.* at least comparable anti-knock effects to NMA, while mitigating at least some of the problems highlighted above.

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.

Accordingly, in one aspect, the present disclosure provides a fuel composition for a spark-ignition internal combustion engine, the fuel composition comprising 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 (hereinafter described as an "octane-boosting additive").

Also provided is a fuel composition for a spark-ignition internal combustion engine, the fuel composition comprising an octane-boosting additive having 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.

In another aspect, the present disclosure provides a process for producing a fuel composition of the present disclosure, the process comprising the step of combining a fuel for a spark-ignition internal combustion engine with an octane-boosting additive described herein.

In another aspect, the present disclosure provides the use of an octane-boosting additive described herein in a fuel for a spark-ignition internal combustion engine. In another aspect, the present disclosure provides the use of an octane-boosting additive described herein for increasing the octane number of a fuel for a spark-ignition internal combustion engine. In a further aspect, the present disclosure provides the use of an additive described herein for improving the auto-ignition characteristics of a fuel, *e.g.* by reducing the propensity of the fuel for at least one of auto-ignition, pre-ignition, knock, mega-knock and super-knock, when used in a spark-ignition internal combustion engine.

In another aspect, the present disclosure provides a method for increasing the octane number of a fuel for a spark-ignition internal combustion engine, said method comprising blending an additive described herein with the fuel. In another aspect, the present disclosure provides a method for improving the auto-ignition characteristics of a fuel, *e.g.* by reducing the propensity of a fuel for at least one of auto-ignition, pre-ignition, knock, mega-knock and super-knock, when used in a spark-ignition internal combustion engine, said method comprising blending an octane-boosting additive described herein with the fuel.

Brief Description of the Figures

Figures 1a-c show graphs of the change in octane number (both RON and MON) of fuels when treated with varying amounts of an octane-boosting additive described

herein. Specifically, Figure 1a shows a graph of the change in octane number of an E0 fuel having a RON prior to additisation of 90; Figure 1b shows a graph of the change in octane number of an E0 fuel having a RON prior to additisation of 95; and Figure 1c shows a graph of the change in octane number of an E10 fuel having a RON prior to additisation of 95.