

## Supplemental Information #2

acpd-2006-0113

### "CO<sub>2</sub> emissions compared to literature values"

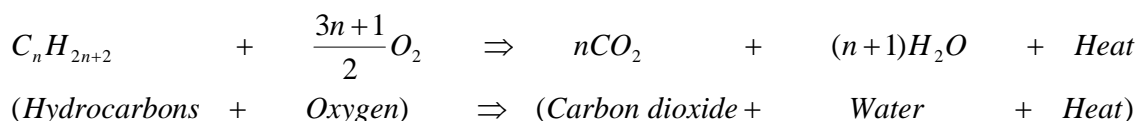
One aspect which draws the attention is the low emission values obtained in this work when compared to those reported in NREL, 2001. If we compare the results after running the hot FTP-75 cycle corresponding to bag #3, we obtain 49.2 g/Km. NREL reports 98.2 g/Km after running the entire FTP-75 cycle (all 4 bags weighted). In order to verify that our results are correct, we have to consider the stoichiometric production of CO<sub>2</sub> taking in to account the properties of the local gasoline used.

PEMEX-MAGNA (lead free) gasoline (SENER-SCFI, 2005)

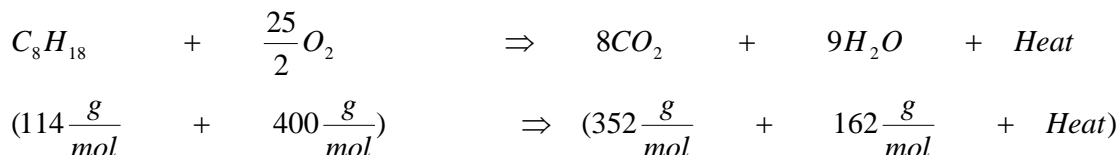
Average density  $\rho = 0.68$  g/L.

Octane number = 87 R+M/2

The ideal combustion process for the oxidation of hydrocarbons follows this equation (Klingenberg, H. 1996):



If the gasoline in hand was a pure iso-octane, then we would have:



And thus the stoichiometric production of CO<sub>2</sub> would be:

$$\frac{352 \text{ g of } CO_2}{114 \text{ g of gasoline}} = 3.09 \frac{\text{g of } CO_2}{\text{g of gasoline}} \quad \text{or} \quad 3.09 \frac{\text{Kg of } CO_2}{\text{Kg of gasoline}}$$

If we consider the octane number to be the measure of autoignition resistance of a gasoline in an internal-combustion engine, where the value is 100 for iso-octane and 0 for the heptane, and relate it to the engine's efficiency we can then write:

$$3.09 \frac{\text{Kg of } CO_2}{\text{Kg of gasoline}} * 0.87 = 2.68 \frac{\text{Kg of } CO_2}{\text{Kg of gasoline}}$$

From this we now can calculate the amount of CO<sub>2</sub> which would be emitted in optimal stoichiometric conditions considering the amount of gasoline consumed after a given driving cycle. This value would then be an upper limit for what is really measured in the tail-pipe, since the combustion is not expected to be perfect.

For the Toyota Prius, reported fuel efficiencies in cities of 52 MPG (miles per gallon) and 57.3 MPG are reported in EPA, 1998 and NREL, 2001, respectively. We obtain fuel efficiencies of 47.7 and 50.6 MPG when running the local MCMA driving sequences, and an average of 73.6 MPG from all the hot FTP-75 cycles run (bag #3 only). We have accounted the unrealistically high fuel economies obtained in our test to be due to the inadequate inertial simulation of the dynamometer used (see section 3 in the text).

Fuel consumption = 73.6 MPG = 31.28 Km/L = 0.032 L/Km

Density  $\rho = 0.68$  g/L.

$$2.68 \frac{\text{Kg of CO}_2}{\text{Kg of gasoline}} * 0.68 \frac{\text{Kg of gasoline}}{\text{Liter of gasoline}} * 0.032 \frac{\text{Liter of gasoline}}{\text{Km driven}} = 58.2 \frac{\text{g of CO}_2}{\text{Km driven}}$$

Higher values from this would suggest that something is wrong with the measurement. We are reporting an emission of 49.2 g/Km of CO<sub>2</sub>, which is approx. 15% lower than the value calculated from fuel consumption. This calculation gives us confidence that the CO<sub>2</sub> measured with this methodology is not being underestimated by a factor of 2 as could be suspected when compared to the other reported values.

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Klingenberg, H. 1996. Automotive Exhaust Emissions Testing. Measurement of regulated and unregulated exhaust gas components, exhaust emission tests. Springer, p. 5.

SENER-SCFI. 2005. Proyecto de Norma Oficial Mexicana. PROY-NOM-086-SEMARNAT-SENER-SCFI-2005, Especificaciones de los combustibles fósiles para la protección ambiental. Diario Oficial de la Federación -D. O. F.-, 20 de septiembre de 2005.