

Enhancement of Benzene Combustion Behavior in Exposure to the Magnetic Field

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Abstract—Reduction of fuel consumption, especially hydrocarbons which are the main sources of energy, is one of the most serious concerns of scientific and also industrial societies. Magnetic field is found to be a potential candidate to enhance the combustion behavior of hydrocarbons. The current study is an effort to investigate the effects of magnetic field on n-hexane and benzene in molecular and electronical scales using UV-Visible and also FT-IR techniques. It is observed that molecules of hydrocarbons modifies by activating new vibrational modes in exposure to strong enough magnetic fields, leading to increase in average kinetic energy and then free energy of fuel. In other words, applying strong enough magnetic field could increase the combustion enthalpy and the reduction the rate of combustion.

Index Terms—Magnetic field, hydrocarbons, combustion enthalpy, fuel combustion

I. INTRODUCTION

Hydrocarbons have been the most important sources of energy for human civilizations throughout the recorded history. The practical importance of combustion cannot be denied, but the massive and uncontrolled chemical changes which take place in this reaction make it difficult to deduce mechanistic paths. The rate of fuel consumption reduces as enhancing the fuel quality. In term of thermodynamics, efforts to increase the combustion enthalpy would be one of the best approaches the reach this goal.

Over the last decades, magnetism has found wide applications in various industries and also medical science, but the main efforts were focused on generation of magnetic field as well as using magnetic materials. In 2006, effects of applying external magnetic field on rheological properties of petrochemical fluids have been studied in Temple University.[1] This research led to proposing a model explaining significantly decrease in viscosity.[2] In fact, it was suggested that clusters of large molecules form and distribute throughout the matrix of smaller molecules, which could explain the decrease in viscosity using Einstein theory.[2]-[4]

Previous empirical studies resulted with the possibility of decrease in fuel consumption due to the applying magnetic field to fuel just before combustion. Based on this idea,

several companies started to manufacture fuel-savers, even though investigations with scientific approaches rarely carried out to clarify all aspects this phenomenon. Therefore, the aim of this investigation is to characterize the parameters govern effects of applying magnetic field on hydrocarbon.

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II. EXPERIMENTAL

Materials used in this investigation were commercial benzene with Euro 4 standard and Merck pure n-hexane. The goal of using n-hexane was to take the advantage of pure chemical composition which significantly simplifies chemical complicated state of benzene. A Bchoice MCG 3.0/9.0 magnetizer was utilized to apply uniform magnetic field in the range up to 5 T.

Three samples of benzene were studied by a JENWAY6705 UV-Visible unit after exposing to uniform magnetic fields with control conditions listed in Table I. Previous studies on hydrocarbons clarified that magnetic field effects gradually vanish after magnetizing due to relaxing of materials. Therefore, period of 5 minutes was set to perform experiments on samples after being exposed to certain field. Fresh, non-magnetized, benzene was tested to form the base line of other samples.

TABLE I: PREPARATION CONDITIONS OF UV-VISIBLE SAMPLE OF BENZENE.

Sample code	Field Strength (T)	Exposure duration (Sec)
B1	0.63	5
B2	0.84	5
B3	1.68	5

Four samples of n-hexane were investigated in this study by UV-Visible technique. Similarly, fresh n-hexane was used to set the base line. Table II presents the preparation conditions of these samples.

TABLE II: PREPARATION CONDITIONS OF UV-VISIBLE SAMPLE OF N-HEXANE

Sample code	Field Strength (T)	Exposure duration (Sec)
H1	0.42	5
H2	0.84	5
H3	1.26	5
H4	1.68	5

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UV-Visible studies led the fact that vibrational states of molecules change in exposure to the magnetic field. Therefore, FT-IR technique was utilized to prove this hypothesis by using a ABBOMEMMB100 FT-IR unit. Therefore, two samples of n-hexane and also two samples of benzene exposed to the magnetic field were examined in this method by setting fresh materials as the reference in each case. Table III and Table IV summarize the preparation conditions samples.

TABLE III: PREPARATION CONDITIONS OF N-HEXANE SAMPLES FOR FT-IR TESTS.

Sample code	Field Strength (T)	Exposure duration (Sec)
H*1	0.42	5
H*2	1.68	5

TABLE IV: PREPARATION CONDITIONS OF BENZINE SAMPLES FOR FT-IR TESTS.

Sample code	Field Strength (T)	Exposure duration (Sec)
B*1	0.63	5
B*2	1.68	5

III. RESULTS AND DISCUSSION

A. UV-Visible

Fig. 1 shows the results of UV-Visible tests obtained from samples B1 through B3 exposed to the magnetic fields of 0.63, 0.84 and 1.68 Tesla, respectively. All samples were examined by setting the fresh benzene as a reference, base line. First peak is measured to be at 219 nm. Second peak seems to be made of a family of absorption modes activated at wavelengths in the range of 240 to 290 nm. A broad peak also is laid at relatively higher wavelengths. The main feature could be observed in this figure, may be the presence of close relation between the intensity of activated modes and the strength of applied magnetic field. As seen, absorption intensity increases as the samples are exposed to higher magnetic fields.

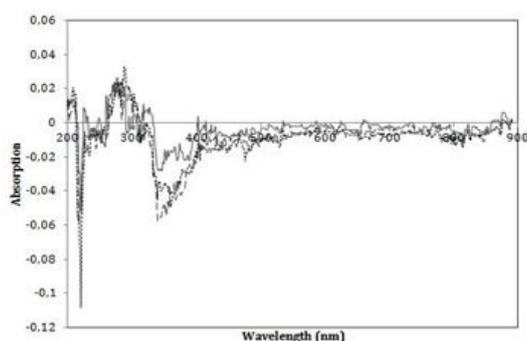


Fig. 1. Magnetization as a function of applied field.

Fig. 2(a) shows the UV-visible spectrum of pure fresh n-hexane. As seen, three different absorption modes may be characterized for which maximum intensity laid at 219, 231 and 267 nm. The obtained peaks are clearly due to true absorption of n-hexane. The sharpness of them, however, is decreased as they are located closely to each other.

Fig. 2 (b) presents the results of UV-Visible tests obtained from samples H1 through H4 prepared by exposing to the different magnetic fields from 0.42 to 1.68 T. The base line of these tests, however, was set to be pure fresh n-hexane. First

peak is measured to be at 219 nm and the two other peaks lay in the range of 240 to 290 nm. As seen, the intensity and also slightly location of absorption peaks of n-hexane changes as magnetic field applied to the specimens. Meanwhile, the magnitude of these changes depend on strength of applies fields. On the other hand, the response of each activated mode is obviously related to their characteristics which be discussed in details later. Owing to such material characteristics dependence of absorption peak changes, negative absorption, compared to fresh sample, could be also observed as well as two other modes result with positive absorptions. It could be also observed that sample H2 shows weaker absorption in comparison with sample H1, even though lower field was applied on sample H1.

Obtained results from n-hexane is in good agreement with the ones observed in the case of benzene samples presented in Fig. 1, even though no broad absorption peak appears at relatively higher wavelengths. In other words, absorption peaks from n-hexane match with the first two ones of benzene.

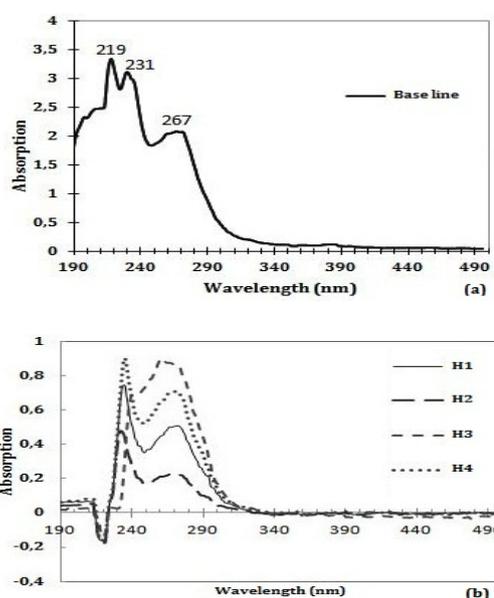


Fig. 2. The UV-Visible spectrum of (a) fresh n-hexane, (b) magnetized samples H1 through H4

Generally, two types of absorption could be considered. First, continuous absorption in which the incident beam, could be electron, laser or light, partly loses intensity as it passes through the homogeneous sample due to scattering phenomenon occurs by interaction between light and substance. The second type of absorptions is, however, caused by electronic transition between electronic levels which are characteristics of materials, usually called true absorption.

The intensity of first type of absorption is closely related to concentration of scattering positions. It is believed that a commercial fuel consists of hydrocarbons with a variety of wavelengths. Experimental studies carried out in this research group, after expectations made previously¹, led to the fact that large molecules of such liquid aggregate to form clusters. Such clustering phenomenon, however, may be intensified at the exposure to the strong magnetic field. In other words, applying strong enough magnetic fields could increase the average size of clusters leading to decrease in

total area of scattering surface. Therefore, the intensity of scattering and then absorption would decrease and appears as the third peak in case of magnetized benzene in Fig. 1. Since this mode of absorption is not dependent to intrinsic of scattering surface, characteristics of material, such a broad curve could be resulted. As evidence for this explanation, no such peak could be observed in case of n-hexane which is a highly pure material.

Similar true absorption could be obtained from hydrocarbons, almost independent to the size of molecules, as could be observed in the case of n-hexane and benzene. In fact, hexane and benzene are almost the same in terms of types of bonds which made them, if small amount of impurity exist in benzene could be neglected. In other words, these two materials are made by similar bonds which could be classified as C-C and C-H, roughly.¹ Therefore, similar electronic transitions occur in both materials leading to similar absorption peaks at 219 nm and in the range of 240 to 290 nm. However, benzene does not show true absorption modes as clear and sharp as n-hexane due to variety of molecular size and also a small amount of impurities.

As could be concluded from obtained curves, the operated UV-visible unit was not precise enough to characterize vibrational states of each electronic transition. However, displacement of absorption peaks and especially changes in absorption intensity represent such significant deviation of vibrational states of magnetized materials compared to the ones with fresh samples.

Actually, decrease in intensity would be caused by increase of nuclear displacement as well as decrease of nuclear displacement which leads to intensified absorption, roughly. The magnitude of changes is also different in each case. However, the definite result could be extracted from this section is the fact that the vibrational states of molecules change by exposing to the magnetic field. However, FT-IR technique can be utilized to confirm this conclusion.

B. FT-IR

Fig. 3 and Fig. 4 show the FT-IR spectrums of benzene and n-hexane. For each material, two samples were tested, a fresh sample and also a magnetized sample which experienced magnetic field of 1.68 T. The main features observed in these figures are the displacement of the magnetized samples curve to higher values, representing substances with more transparent character, and also several new absorption modes mainly laid at relatively short wavelengths. Broad peaks pointed by arrows originated from holder material, KBr. Fig. 3 and Fig. 4 clearly confirms the hypothesis of changes in vibrational states of molecules in exposure to the magnetic field.

Fig. 5 presents the results of FT-IR tests performed on samples of n-hexane exposed to the magnetic fields of 0.42 and 1.68 T. The main feature characterized through this attempt was the presence of lower limit for field strength in order to activate new absorption modes. For instance, there is no significant sign of new vibrational modes in case of sample experienced magnetic field of 0.42 T. No upper limit, however, was observed through this study. Similarly,

absorption peaks of holder material are shown by arrow in the figure. Similar features could be observed in Fig. 6 which presents the FT-IR spectrums of benzene exposed to the magnetic fields of 0.63 and 1.68 T.

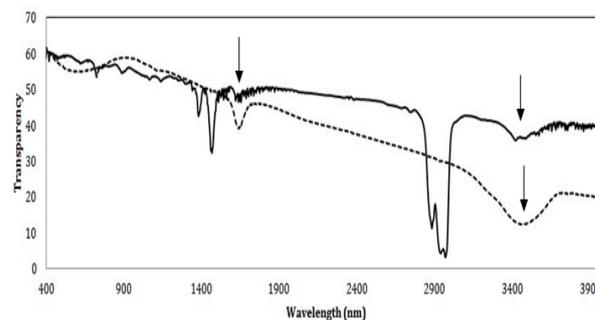


Fig. 3. FT-IR results obtained from fresh n-hexane (dashed curve) and sample H*2 (continuous curve).

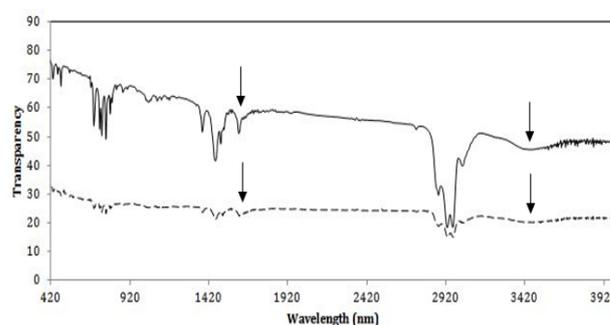


Fig. 4. FT-IR results obtained from fresh benzene (dashed curve) and sample B*2 (continuous curve).

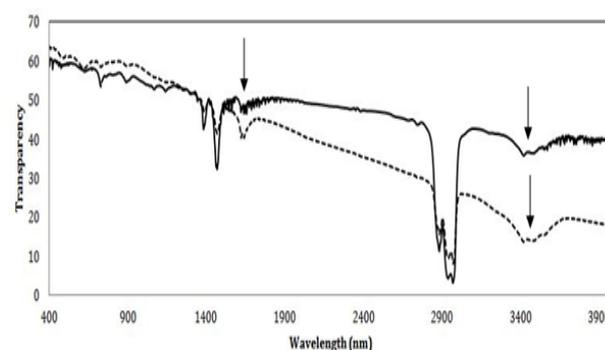


Fig. 5. FT-IR results obtained from sample H*1 (dashed curve) and H*2 (continuous curve).

It has been realized that strong enough magnetic field can activate several new vibrational modes, especially the ones located at relatively short wavelengths, leading to increase in kinetic energy of molecules. Average free energy of molecules, therefore, increases by exposing to strong enough magnetic field. Fig. 7 illustrates how such changes can affect on combustion enthalpy of fuel. It is assumed that free energy of products is unchanged because all primary bonds break to form new bonds during combustion. Therefore, products do not experience magnetic field effects. Therefore, the combustion enthalpy or combustion heat increases leading to enhancement of fuel quality and then reduction in fuel consumption. This explanation confirms the reports given by those companies which manufacture magnetic fuel saver. However, many proposed designs failed because the required conditions of applying magnetic field such as strength did not satisfied.

¹ Benzene is supposed to be consisted of a range of saturated hydrocarbons (Alkenes), but there is always a small content of impurity in commercial benzene.

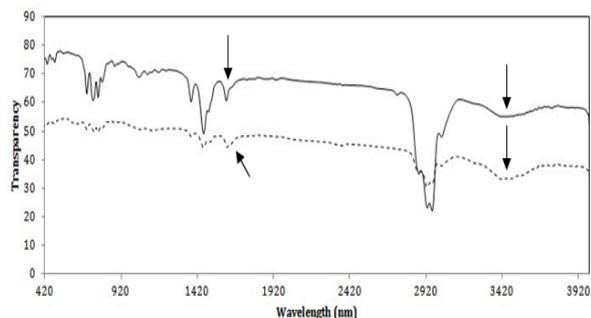


Fig. 6. FT-IR results obtained from sample B*1(dashed curve) and B*2(continuous curve).

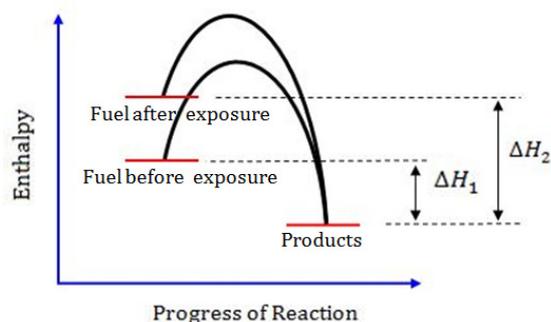


Fig. 7. Schematic view of magnetic field effect on combustion behavior.

IV. CONCLUSION

- 1) Relatively large molecules within benzene aggregate in exposure to strong enough magnetic field. Owing to decrease in total scattering surface after clustering, the intensity of absorption in UV-Visible test decreases as a broad peak implying the fact that this type of absorption is not characteristic to material.
- 2) Magnetic field can change the Frank-Condon factor (FC) of electronic transition in UV-Visible leading to change in intensity and also the position of peaks in spectrum. This is closely connected with vibrational states of molecules.[5]
- 3) New vibrational modes activate as molecules exposed to strong enough magnetic field as well as changes in former modes of vibration. There will be no effect if relatively weak magnetic field is applied on materials. In fact, a lower limit for field strength could be considered depending on material. Activation of new vibrational modes causes increase in average kinetic energy of molecules leading to higher free energy. Therefore, combustion enthalpy rises as material experiences strong enough magnetic fields. This also results with reduction in fuel consumption.
- 4) There is no difference between hydrocarbons in terms of

magnetic field effects. In other words, this concept could be generalized in case of other hydrocarbons.

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