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Synthesis and Characterization of Core-Shell Modeled AlMCM-48/HZSM-5 Composite Catalyst and Studies on Its Catalytic Activity in Cracking of Pongamia Oil into Bio Liquid Products

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Abstract

The growing demands on alternative fuels which can be used in present-day engines have imposed strong necessity on this proposal. Biofuels, the hydrocarbons less than C_{18}, are believed to be the promising alternative fuel. In the present work, the abundantly available pongamia oil was experimented to produce biofuel using hydrothermally synthesized porous catalysts such as HZSM-5 and AlMCM-48 and synergistic composite catalyst AlMCM-48/HZSM-5. Characterization techniques such as XRD, BET, TPD, and TEM were used to study the characteristics of catalysts. The catalytic activity of the catalysts in cracking of pongamia oil at optimized reaction conditions—temperature, 400 °C; WHSV, 4.6 h^{-1}; and reaction time, 1 h in a pilot scale stainless steel high pressure fixed bed reactor (100 ml volume; 15 mm id)—was studied. Among mesoporous AlMCM-48 with different Si/Al ratios, AlMCM-48 (27) efficiently cracked 69% of pongamia oil into 45% bioliquid products (BLP) with 34% and 44% selectivity towards green gasoline (GG). The composite catalyst was synthesized with the most active microporous catalyst (HZSM-5) as core and mesoporous material AMCM-48(Si/Al = 27) as a shell. The composite material AlMCM-48/HZSM-5 proved to be an excellent catalyst in converting 97% of pongamia oil into 70% bioliquid hydrocarbons with 70% selectivity towards gasoline. The calorific value (ASTM D 240) of the biofuel was observed to be higher, while the viscosity (ASTM D 445) and specific gravity (ASTM D 1298) were found to be lower than biodiesel produced through transesterification process.

Keywords Pongamia oil · Micro/meso catalyst · Cracking · C_5-C_9 hydrocarbons · Pilot-scale fixed-bed reactor · Green gasoline

Introduction

The survey predicts that road transportation sector demands nearly 80% of total energy consumption in the form of liquid fuels. For the past few years, the quest for alternative fuel has alarmingly increased due to global warming, severe environmental pollution, and a drastic rise in petroleum price [1]. To overcome this crisis, research is done on various alternative forms such as wind, sunshine, and biomass. The interest of deriving fuel from biomass has attracted significant research due to its abundance and production of all the three phases of fuels [2]. The liquid fuel obtained from biomass is termed as biofuel and such fuel should be eco-friendly, sustainable, free from sulfur and nitrogen compounds, and biodegradable [3].

Various processes such as transesterification, pyrolysis, fermentation, hydrocracking, and catalytic cracking have been performed for the conversion of vegetable oils into fuels [4, 5]. Biodiesel obtained through transesterification of these oils cannot be used as such in the automobiles and hence needs to be blended with the commercially available fossil fuels such as diesel or petrol [6, 7], and it also does not burn cleanly as it forms gums on engines [8, 9]. The energy efficiency of bioalcohol through fermentation was found to be as low as 1.1 because the distillation of bioalcohol from the fermentation mixture requires 50% of the cost of production of bioalcohol [10]. The drawbacks of biooil obtained from pyrolysis are as follows: (a) it is highly viscous, corrosive, and thermally unstable [11], (b) it has lower heating value (HV) which is approximately 40% less than that of fuel oil, (c) its composition mainly contains oxygenated compounds which are very similar to that of the original biomass and is very different from petroleum-derived fuel, and (d) it

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Handling of Indeterminacy for Trust Aware Energy Consumption Using Adaptive Intuitionistic Fuzzy Environment in Wireless Sensor Networks

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Abstract: ***In Wireless Sensor Network Environment (WSN), the most critical parameter of sensor nodes is the optimal usage of life time. An efficient WSN protocol needs to conserve energy as the main objective of maximizing the network lifetime. Further, secure topology construction is also included in this work, because trust value is considered as a vital factor which affects the behavior of nodes. The incompletion or inconsistency in gathering information of sensor nodes is not well-handled in most existing techniques for the selection of cluster head, taking into account trust Value, Residual Energy, Shortest Path (distance), and Number of Neighbor Nodes. This paper has devised a two-stage optimized energy consumption scheme termed AIFMDMCS. This work elects cluster heads under the condition of indeterminacy in selection criteria with the aid of Intuitionistic fuzzy Logic based decision making. These cluster heads are responsible for collecting and integrating the data received from cluster nodes. The integrated data packets are transferred to the base station using Intuitionistic fuzzy inference engine for improved load balancing, in case of high traffic and presence of collision detection. The simulation results demonstrate that this approach is more effective in protracting network lifespan, because in WSN, it finds the optimal shortest route, and, during vagueness while electing both cluster heads, the degree of indeterminacy is considered.***

Keywords: ***Wireless Sensor Networks, Energy Consumption, trust aware, Cluster Head Selection, Intuitionistic Fuzzy Logic, Uncertainty, indeterminacy***

I. INTRODUCTION

Wireless Sensor Network (WSN) is generally used for sensing, collecting and forwarding the data Wireless sensor networks in grouping a large amount of smaller sensor nodes. The sensor nodes are placed randomly or manually into the specified area. The power consumption of the sensor nodes and lifetime of networks are the most challenging issues in the WSN environment [27]. In WSN, clustering is one of the most challenging issues and can be mainly focused on for improving scalability to enhance the lifetime of the network. Initially heuristic approaches were used. The main drawback of this approach is that it will select a node with a very low energy. Later Meta heuristics approaches were used, which could deal directly with the gateways and manage them to the maximum energy of the nodes [28, 29]. Sensor nodes are energy constrained. Once the node is deployed it cannot be recharged further. The characteristics of WSN's are battery operation, short range communication and nodes with no limited central manager. Improving network lifetime is the fundamental challenge of wireless sensor networks [27]. The sensor nodes consist of low power, and an irreplaceable battery which has a limited lifetime. Sensor nodes typically use irreplaceable power with the limited capacity, and the node's capacity of computing, communicating and storage is very limited. This feature of sensor nodes requires WSN protocols to conserve energy which is the main objective of maximizing the network lifetime. In order to accomplish extended lifetime of the WSN, it is essential to utilize the energy consumption of the sensor node precisely and discover the shortest path for transferring the data packets to the base station more resourcefully. In most real time applications, the information of the sensor data is really vague to collect because of the frequent changes due to their mobility. However, there are several existing techniques available for energy consumption-based routing techniques. There is no complete proof to provide better optimization in case of uncertainty in selection of cluster head which itself contains imprecise data. This paper has devised an Adaptive Intuitionistic Fuzzy Multi-Attribute Decision-Making (AIFMADM) for overwhelming those two challenges in two different stages.

Stage 1:

In this stage a prominent election of cluster head is done by considering indeterminacy as a major factor in situation of uncertainty during selection process among cluster nodes.

The criteria used for electing sensor node as cluster head are fixed using the degrees of membership, non-membership and hesitation for residual energy, distance among cluster nodes and the number of neighbor nodes. The node which has a high degree of membership towards these three criteria will be selected as cluster head.

Stage 2:

After the prominent cluster head is selected, the energy consumption should also be considered in route selection. Each cluster head should collect data from the cluster nodes and aggregate and transfer them to Base Station. So, an enriched Intuitionistic fuzzy rule inference system is framed using the degrees of membership, non-membership and hesitation of residual energy, distance, delay, bandwidth and queue size for the finest route selection among cluster head nodes to reach the base station in case of high traffic and presence of collision detection. The simulation is done using NS2 to prove that this proposed optimal routing scheme consumes energy commendably.

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II. RELATED WORK

In this section an elaborative study on various existing research works is done on Energy Consumption in wireless sensor networks using cluster head formation and route selection.

Dilip Kumar *et al*. [1] devised a scheme by assigning a different threshold to each node and based on the assigned weights to the nodes the cluster head is selected. On the basis of the life time of network and stability of the sink, the result showed that the proposed work performed better. Babar Nazir *et al.* [2] introduced an algorithm that used mobile nodes to fill the gap formed by any energy hole or hot spot. It was used so that we could use the energy in a balanced way through the network and increase the lifetime of the sensor network. Ben Alla Siad *et al.* [3] presented a model which evenly distributed the load of energy within the sensor nodes by performing adoptive clustering which balanced the leach protocol efficiently. This protocol reduces node failure probability through efficient consumption of energy. Rashed *et al*. [4] developed a protocol to enhance the sink stability of a sensor network. It also introduced a clustering scheme with a chain routing algorithm to enhance the energy and stable period constraints. By using this algorithm, the link between the cluster heads was framed.

Xiaojiang Du *et al.* [5] developed a method which held a large number of sensor nodes with low power and a low number of sensor nodes with high power. Here the network was assumed to be static and each node was aware of its location. Hence these techniques could not be adapted in more real time applications. Jung-Hwan *et al.* [6] introduced clusters with uneven size where clustering was dynamic and produced variations in size. Sanjeev *et al.* [7] developed an approach for clustering the heterogeneous sensor nodes to increase their life. The communication cost was reduced considerably. Incel *et al. [*8] handled false data collection in WSN, using Time Division Multiple Access (TDMA). It focused on scheduling process under tight time scheduling and produced high throughput under high load conditions. It reduced the bottle neck nodes for scheduling process by constructing spanning tree. Thus, it reduced the scheduling length of the process.

Xu *et al* [9] developed data aggregation in an efficient way by minimizing the delay. This work was collision free during data transmission in WSN. Kasbekar *et al* [10] introduced the techniques designed by polynomial-time used by a distributed algorithm. One of the significant advantages in distributed algorithm was that it could achieve maximum lifetime. Kajal *et al* [11] elected the RaSMaLai algorithm. This algorithm prolonged the network lifetime by load balancing and was also used to randomly switch a few of the selected sensor nodes to other paths which held fewer loads. Biswas *et al* [12] in their work proposed an energy efficient hierarchical routing protocol for Wireless Sensor Networks to increase the network lifetime. was proposed. They considered the critical issue as nodes could not be recharged and/or replaced frequently.

Tayeb *et al* [13] proposed to improve the utilization of energy of sensor nodes for traffic control, energy consumption and increase of life time by adapting credit based energy efficient routing algorithm which selected the cluster head based on the priority of relay sensor nodes. To solve this, an energy efficient cluster method with cluster-based redundancy discovery and sleep algorithm for energy efficient routing was proposed. Sree Vidya and Nagaraj [14] in their work proposed a cluster-based approach for finding redundant sensor nodes in WSN. When the data transfer rate was less than the predefined threshold value, then a clustering sleep scheduling algorithm was initiated by them to overcome the collision problem by changing all other nodes in the cluster to sleep mode. Muthusenthil and Kim [15] in their work developed a secure hybrid routing protocol for selecting the cluster head based on their weight factors, and greedy forwarding method was used for selecting the best route. It secured packets using both symmetric and asymmetric cryptosystem.

Din *et al* [16] proposed cluster head selection using multi-tier algorithm using fuzzy logic which used sensor nodes consistently, and the nodes died consecutively as the data enlarged. For these reasons the sensor nodes consumed their energy effectively hence persisting with the wireless network lifespan. Guihaichen *et al.* [17] formulated a source driven sensor network protocol which selected cluster heads using neighboring nodes' residual energy. This protocol was time consuming and held an uneven cluster size because of its variable cluster count. Marin *et al*. [9] framed a cluster with a low construction and maintenance overhead. Each node in the cluster was set to a unique weight and unique identifier. A node with the highest value was elected as the cluster head. Chong Wang *et al.* [18] introduced the protocol which saved the cost of energy by splitting large clusters into smaller ones using sub cluster head. It increased the network life time by activating a single node which was involved in packet transfer, while the remaining nodes were kept in sleeping node.

D. Kumar *et al.* [19] determined the weighted probability of each sensor node to elect a node as cluster head in WSN environment. The presence of variation in cluster count produced cluster with varying size. B. Elbhiri *et al.* [20] extended the work of DEEC by sending significant information of the sender to the base station and keeping the other nodes in a sleeping node. This protocol was application specific.

ElbhiriBrahim *et al.* [21] in their work selected advanced nodes as cluster head during the initial transmission, which decreased, the cluster head selection based on the probability. It also reduced the intra cluster transmission.

The existing works discussed above failed to deal with the real time problem of uncertainty in the selection of cluster heads and the optimal route when the information collected for processing was insufficient, inconsistent or incomplete. Thus, this proposal focuses mainly on handling such uncertainty by introducing the intuitionistic fuzzy decision matrix, which extends the degree of hesitation which is not handled by the fuzzy logic.