CORN STOVER LIQUIDS FOR STABILIZING COARSE SAND AND FINE SOIL PARTICLES AGAINST WIND FORCE: A LABORATORY WIND TUNNEL STUDY

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ABSTRACT

The applicability of using corn stover liquids as coarse sand soil particles stabilizer (bio-binder) material was studied. The corn stover powder (CS) was liquefied in ethylene carbonate (EC) in the presence of dilute sulfuric acid. The liquid samples were prepared with 4 levels of CS/EC mixtures (20%, 22.5%, 25%, and 30%, w/w), 2 levels of liquefaction temperature (140 °C, and 160 °C), and varied reaction times (30~90 min). The insoluble residue ratios for the CSLS increased with higher CS/EC mixture, lower reaction temperatures and shorter reaction times. While the viscosity in the CSLS increased with higher CS/EC mixture, higher reaction temperatures and longer reaction times. The air dried pre-treated coarse sand soil samples covered with CSLS were placed in a tunnel subjected to wind speeds ranging from 6 m/s to 18 m/s. The crusts developed with the CSLS on the coarse sand soil surface could withstand wind speeds up to 10 m/s, beyond this speed the deformation in the crust with a gradual increase in the erosion rate was observed. The present work concluded that the adhesive forces of all the CSLS samples had nearly the same resistance effects to the wind flow irrespective to the preparation conditions (CS/EC ratios, reaction temperature and reaction time) and the viscosity. Also the crust developed on the coarse sand soil samples showed high resistance to wind erosion to a limited wind speed; however, beyond that limit the coarse sand soil particles are no longer stabilized.

Key words: *corn stover, liquefaction, soil conservation, wind erosion.*

INTRODUCTION

Wind erosion is considered to be a principal mechanism and important form of soil degradation [1], and [2]. Accordingly, it recognized as one of the most serious environmental and agricultural problems worldwide, which has intensified in recent years [3], and [4]. Wind erosion is mainly confined to the so-called drylands, which comprise arid, semi-arid, and dry sub-humid areas, in such ecosystem the following conditions frequently occur: a loose, dry, finely divided soil and a smooth land surface devoid of a vegetative cover, due to low precipitation, large fields, and strong winds [5]. Basically, wind erosion can be defined as the physical transport process of soil particles blown away by an air stream, so the wind is the forcing mechanism of wind erosion [1], and the threshold friction velocity (TFV) is the force of wind required to detach particles from soil surface and controlled by soil surface characteristic [6]. Consequently, wind speed as low as 5~7 m/s (11~15 mile/hr) at 3 m above the soil surface can initiate soil movement under high erodible field conditions by modes of transport creep, saltation, and suspention [7]. In addition, the size and stability of the soil aggregates are primary factors that affect soil susceptibility to wind erosion [8]. The biding agents of soil aggregate vary also [8], while aggregates > 2000 μm are held together by a fine network of roots and hyphae in soils with high contents of organic carbon (> 2%), aggregates between 20 μm and 250 μm consist largely of particles 2~20 μm diameter, bonded together by various cements including persistent organic materials, crystalline oxides, and highly

disordered aluminisilicates. By the same token, water-stable aggregates 2~20 μm consists of particles < 2 μm diameter bonded together very strongly by persistent organic bonds. Also aggregates between 2 μm and 20 μm are an association between live bacteria cells and clay particles [8], and [9]. Thereafter, aggregates smaller than 0.84 mm in diameter are considered as erodible by wind [9], and the proportion of those aggregates in the upper 25.40 mm of the soil surface defines the wind erodible fraction. As a result, aggregates resistance against disrupting forces can be estimated by means of their dry aggregate stability (DAS), which is considered an index of soil resistance against wind erosion [10].

Conventionally, many practices that have been used to control soil wind erosion [11]. But the practices which can stabilize sand soil particles against wind force were briefed by [12] in two steps: temporary stabilization which can be done by any material that stops surface sand movements, and then biological stabilization which consists of establishing a permanent vegetative cover and this step depends upon how efficient the temporary stabilizer. Furthermore, [13] illustrated that temporary stabilization may be done by using vertical barriers or horizontal protection. While vertical barriers consist of fences of appropriate height, thickness, porosity, and arrangement [14], [15]; horizontal protection involves adding clay and organic matter to sandy soil [16], using biological crusts on soil which empower soil dry aggregates on the surface against wind erosion [17], and applying water, oil (low-gravity asphaltic oil, high gravity waxy oil, and crude oil), and chemical soil stabilizers [18].

Practically, effective utilization of lignocellulosic biomass has been achieved by applying chemical and biochemical techniques, such as pyrolysis [19], modification [20], hydrolysis [21] and liquefaction [22]. Especially for liquefaction in solvents, biomass could be decomposed into liquid at mild temperature and atmospheric pressure [23], and the liquefaction was influenced mainly by liquefaction solvent and catalyst, as well as reaction temperature and reaction time [22]. Generally, the slow liquefaction rate or lower temperature generates higher levels of char, while the faster liquefaction rate or higher temperature generates higher levels of liquids and gaseous products [24]. In other words, liquefaction yield increased with increasing time and temperature and better liquefaction achieved at 2 hrs and 160 °C, and a further increase in time and temperature resulted in a depressed increase in liquefaction yield [25]. The costs as well as the mechanical properties are the main constraints that limit the wide use of biodegradable materials [26]. Thus, [27] suggested that any increase in the corn stover (CS) charge could contribute to decrease in the liquefaction costs. However, liquid co-product produced during biofuel production using biomass that are rich in lignin contents have been used in many traditional applications which include but are not limited to concrete admixtures, binders, well drilling mud, vanillin production, dispersants, and soil particles and dust control [28].

Fewer research has been conducted until now on the material that utilizing biomass liquids for soil particles adhesive or binder [29]. Accordingly, this paper focused at study the applicability of using different corn stover liquids produced at different experimental conditions to serve as coarse sand soil particles horizontal barriers, mainly through enhance sand soil particles adhesive force against wind force and therefore can control or mitigate the rate of sand soil particles detachment.

MATERIALS AND METHODS

A. Materials

Corn stover (CS) was collected from a local farm in suburb areas around Beijing of China. Then corn stover was milled, screened, oven dried and weighted; only the fractions with particle size of 20~80 meshes and moisture content of 6%~9% were employed for the study. Ethylene carbonate (EC, 99.90%, v∕v) was used as solvent in the liquefaction process, and sulfuric acid (98.8%, v∕v) as catalyst. Water and silicon were used as blowing agent and surfactant, respectively. All these chemicals were of analytical reagent grades, which were obtained from commercial sources in Beijing.

Sand soil sample was dried in the open air for 7 days, and then sieved with 1.2 mm~0.16 mm sieve shaker. A soil sample was then stored in a plastic bag for size determination and some physiochemical analysis prior to stabilization experiment.

B. Laboratory preparation of corn stover liquids (CSL$_S$)

The experiments were conducted at Agricultural Processing Laboratory, College of Engineering, China Agricultural University. Different amount of the dried corn stover powder (40 g, 45 g, 50 g, and 60 g) each was added to (200 g) ethylene carbonate. This prepared CS/EC mixtures of (20%, 22.5%, 25%, and 30%), was then liquefied under two levels of liquefaction temperature (140 °C and 160 °C), and 4 levels of liquefaction time (30 min, 50 min, 70 min, and 90 min).

The liquefaction chemicals (ethylene carbonate, 200 g; and sulfuric acid, 7 g) with dried corn stover powder whose amount was weighted according to the designed CS/EC mixtures were placed in a three-neck flask (1000 ml) equipped with a reflux condenser; a thermometer; and a motor driven-stirrer. The main function of the reflux condenser is to condense and reflux the materials which would be produced in the liquefaction process and could be evaporated at the specified temperature. The mixed materials in the flask then refluxed at a desired temperature for a predetermined period of time, with continuous agitation during the liquefaction process to obtain homogeneous liquefied products. The flask was then immersed into cold water to quench the reaction. For all experiments, the liquefaction process was done at the atmospheric pressure.

C. Measurement of liquefaction rate

The insoluble residue (unliquefied corn stover) ratio (IRR) of the CSLS was measured as illustrated by [30], and then the rate which was used as index for liquefaction efficiency was calculated as suggested by [31]:

$$liquefaction\ rate\ = \frac{W_0 - W}{W_0}$$

Where: W_0 is the weight of the corn stover sample before liquefaction, and W is the weight of insoluble corn stover residue obtained after liquefaction.

D. Measurement of viscosity

The viscosity of the CSLs was determined following the method applied by [30], and by using a viscometer (Model: NDJ-85, Cany Precision Instrument, Shanghai, China) at 25 °C.

E. Soil particle size with some soil properties

Soil particle size was obtained referring to the USDA classification scheme [32], the soil moisture content and the soil bulk density were calculated as suggested by [33], and the soil pH was obtained in accordance with [34] method using a pH meter (Model: Sartorius AG PB-20, Switzerland).

F. Lab wind tunnel experiments

The laboratory experiments for the lab wind tunnel were conducted in General Experimental Hall, College of Water Resources and Civil Engineering, China Agricultural University; and according to the lab conditions as in the following steps:

To determine the effect of the CSLS on the sand soil particles stabilization, the different CSLS that were prepared with different CS/EC mixtures (20%, 22.5%, 25%, and 30%) and the 2 different reaction temperature (140 °C and 160 °C), and the 4 different reaction time (30, 50, 70, and 90 min), were employed as CSLS samples. The CSLS samples were then heated in the water bath for 2 hours at 70 °C to decrease the viscosity of the stored CSLS and to ease its pumping out. Empty trays (50 cm×45 cm×15 cm) were weighed and then filled with the prepared sand soil with a

careful leveling. The filled trays were re-weighed and labeled to be ready for the coming CSLS application. About (20 g) CSLS samples were sprayed individually on the surface of the leveled sand soil (about 1.5 m above the labeled trays) using a small hand pump by means of compressed air stream from electric air compressor (Model: AIRTATE 0.2/8 D-3 (II), Shanghai, China), at constant pumping pressure (0.8 MPa). The weight of each tray was determined, recorded, and remarked, each was then known as experimental sample. All the experimental samples were then exposed to 5~7 days drying period at ambient temperature (15°C~20 °C). A wind tunnel (Model: NYB, The New York Blower Company, USA), has a dimension of (17 m×9.7 m×0.75 m) was used, and the wind speed in the tunnel was pre-adjusted according to the classified effects of wind erosion on soil (surface creep, saltation, and suspension). Accordingly, the wind speeds applied were 6 m/s, 8 m/s, 10 m/s, 12 m/s, 14 m/s, 16 m/s, and 18 m/s with a speed application interval of 5 min (i.e. raising speed gradually 2 m/s each 5 min), the speed was measured in the free opens of the wind tunnel using digital anemometer (Smart Sensor, Model AR836, Hong Kong Hen Gao Electric Group, Hong Kong, China). The data related to the effect of the wind tunnel speed on the treated sand soil samples were determined as soil weight lost.

G. Statistical analysis

Data were obtained from three separate samples and then averaged. Data were analyzed statistically by Analysis of variance and then means were separated using Microsoft Office Excel 2007 (Microsoft Corporation, USA), and the MATLAB 2011a (Mathematical Computing Software, Natick, USA).

RESULTS AND DISCUSSIONS

The liquefaction rates and viscosities of the corn stover liquids

Fig. 1 shows the results of liquefaction efficiency of CSLs (20%~30% CS/EC) prepared at 140 °C and 160 °C at different liquefaction times (30 min ~ 90 min). The liquefaction rates of all CSLS samples prepared at 140 °C and 160 °C were at minima at 30 minutes and they increased gradually as the liquefaction time prolonged, and reached their maxima at 90 minutes. Except for a CS/EC mixture of 22.5%, it is noteworthy that the liquefaction rate of the CSLS samples treated at 140 °C increased rapidly at the first 50 minutes and then the rate of increase slowed down with time. At 160 °C, the 20% and 22.5% CS/EC samples behaved similar as at 140 °C. While with CS/EC mixtures of 25% and 30% the steady increase in the liquefaction rate extended to 70 minutes and then the rate of increase started to slow down. Moreover, 20% CS/EC samples heated at 140 °C and 160 °C showed higher liquefaction rates compared to 22.5% CS/EC and as the percentage of the CS increased in the sample the liquefaction rate further decreased. Accordingly, 30% CS/EC had the lowest liquefaction rate. It can be seen from Fig. 1 that treating the CS/EC samples at 160 °C resulted in better liquefaction rate than that at 140 °C. However, low CS/EC mixture and high reaction temperature and time gives better CSLs yield, these results are similar to that reported by [35]. The results of viscosity of the CSLS prepared at 140 °C and 160 °C at different liquefaction times (30 min ~ 90 min) are presented in Fig. 2. The viscosities of CSLS at 140 °C and 160 °C were in sequence. The viscosity of the sample was increased as the amount of CS in the liquid increased. Hence, the CSLS with 30% CS/EC showed the highest viscosity. The viscosity of the liquid samples (20~30% CS/EC) at 140 °C and 160 °C increased steadily with the progress in reaction time whereas at 90 minutes the highest viscosity was found. A positive correlation between CSLS viscosity and the solid content as well as the high liquefaction temperature and time was reported [26], and [29].
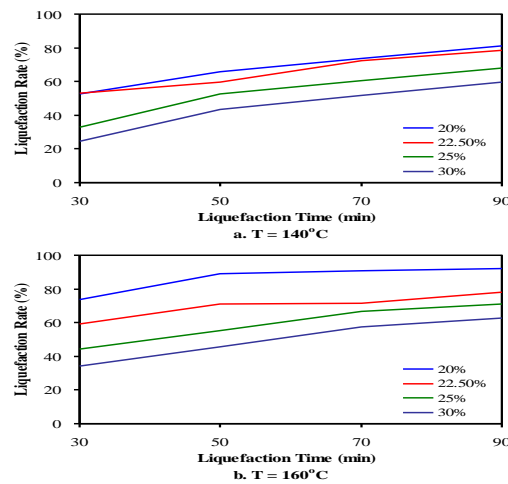
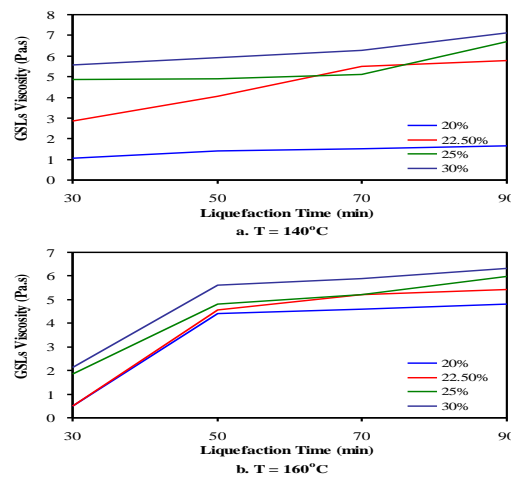**Fig. 1.** Liquefaction rate for different CS/EC mixtures at 140°C and 160°C.

Fig. 2. Liquefaction viscosity for different CS/EC mixtures at 140°C and 160°C.

The effects of the corn stover liquids on the sand soil particles stabilization

According to the classification scheme of USDA standards for soil particle size, and with referring to Table 1, that one of the soil sample falls in the coarse sand soil type and the other soil as fine soil which is a mixture of fine coarse sand, silt and clay.

The sticking abilities of the CSLS samples produced at 140 °C and 160 °C on the coarse sand soil particles subjected to different predetermined wind speeds are shown in Fig. 3. All the samples showed resistance to movement (without deformation in the CSLS coarse sand soil crusts) under the wind speed of 6~10 m/s. But in some samples a gradual increase in the wind speed up to 12 m/s resulted in partial deterioration of the soil crusts accompanied with a tiny detachment of the coarse sand particles. When the wind speed reached 14~16 m/s higher deterioration of the CSLS and coarse sand soil crust was observed in the most of the samples, as a consequence, more detachment of the coarse sand soil particles was found. However, more and more crusts deterioration occurred when the wind speed was increased beyond 16 m/s that resulted in extreme negative effects on the soil particles for the whole coarse sand soil samples. Most of the samples curves showed a tendency that the difference existed in the starting points continued with no change during the wind tunnel test until the upper limits of the crusts strength. This indicate that below this upper limits the stickiness or the strength force of the CSLS acting on the surface of the coarse sand soil particles samples was enough to resist the effect of the wind speed. But after that upper limits CSLS coarse sand soil particles samples showed different and fluctuated trend attributing mainly to the difference in the application rate of the CSLS on the samples surface, which in turn revealed different crusts surface strength and thickness, and thus different wind speed resistance. In general, the findings indicated that the CSLS succeeded in sticking the coarse sand soil

particles together by acting as cement material, simultaneously helped to develop a soil crust and thus increased the ability of the coarse sand soil to resist the wind force, this sticking ability may attributed to some rheological properties such as liquids viscosity and also high organic carbon as supported by [9]. Besides, all the CSLS and coarse sand soil particles crusts investigated showed nearly the same effects (without loss when the wind speed not exceeding an upper limit) within a wide range of wind speed and with no apparent differences between the CSLS samples under the described liquefaction temperature and time.

TABLE I: physiochemical properties of the soil samples

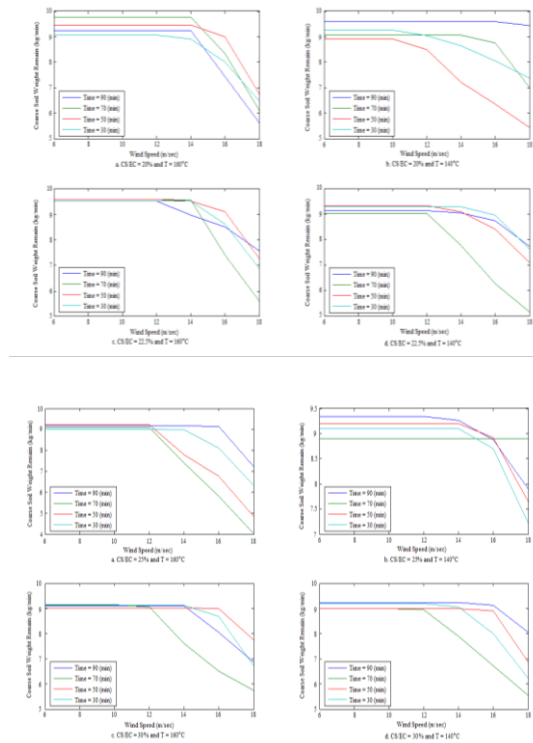| Soil type	Soil size (mm)	Moisture content (%)	Bulk density	Soil pH
Coarser particles	1.20 ~ 0.16	0.21	1.50	7.95
Finest particles	≤ 0.16	0.30	1.18	7.88

Fig. 3. Coarse sand particles weights remain at different CS/EC mixtures.

The rate of the wind erosion on the coarse sand soil relative to the wind speeds applied with the time interval of 5 minutes is shown in Fig. 5. It was revealed that for most of the samples wind speed of 6 m/s ~8 m/s applied on the crusts developed from the CSLS and coarse sand soil particles resulted in zero erosion rates, which indicate that within this wind speed the crusts strength was strong enough to resist the wind force. Thereafter, a gradual increase in the wind speed to 10 m/s ~12 m/s caused a gradual and continual deterioration of the CSLS and coarse sand soil particles crusts of the most samples, exposing more soil particles to direct wind force which caused a gradual increase in rate of coarse sand soil erosion. Increasing the assind speed beyond 12 m/s (14 m/s, 16 m/s, and 18 m/s) all the CSLS and coarse sand soil particles crusts moved in high rates, resulting in a concurrent increase of their erosion rate. Generally, a gradual increase in erosion rate of the coarse sand soil with wind speed suggested the high adhesive force of CSLS and the coarse sand soil particles crusts at first versus a low wind force at the low speed, and then the

opposite is true with increasing the wind speed. Also it is well mentioning that the CSLS and coarse sand soil crusts start to move by wind force at some point (s) within the sample, which in turn ease and accelerate crusts deterioration more than the other samples, despite the CSLS, and its liquefaction conditions.
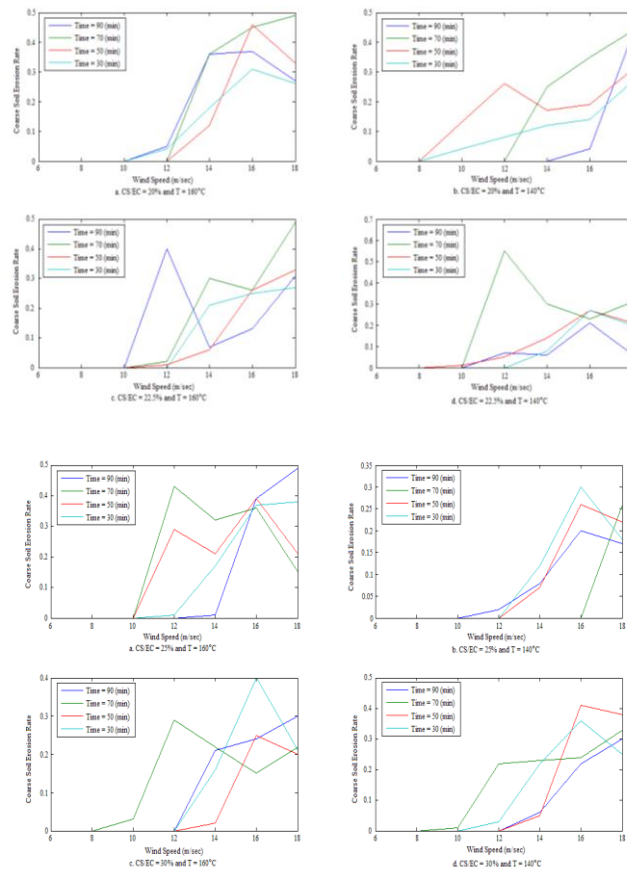

Fig. 4. Coarse sand particles erosion rates at different CS/EC mixtures.

ACKNOWLEDGMENTS

REFERENCES

[1] J. R. Williams, C. A. Jones, P. T. Dyke, "A modeling approach to determining the relationship between erosion and soil productivity," *Transaction American Soiety Agricultural Engineering*, vol. 27, pp. 129-144, 1984.

[2] G. S. Okin, B. Murray, W.H. Schlesinger, "Degradation of sandy arid shrub-land environments: observations, process modeling, and management implications," *Journal of Arid Environment,* vol. 47 no. 2, pp. 123-144, 2001.

[3] X. Yang, G. Chapman, R. Yeomans, "Assessing soil erosion risk after severe bushfires in New South Wales, Australia using RUSLE and MODIS," *7th International Symposium on Digital Earth,* Perth Australia, August 2011, pp. 23-25,.

[4] L. Gomes, J. L. Arrue, M. V. Lopez, G. Terk, D. Richard, R. Gracia, M. Sabre, A. Gauddichet, J. P. Frangi, "Wind erosion in a semi-arid agricultural area of Spain: the WELSONS project," *Catena*, vol. 52, pp. 235-256, 2003 .

[5] J. R. Williams, A. N. Sharpley, D. Taylor, "Assessing the impact of erosion on soil productivity using the EPIC model," In: *J. Boardman, I.D.L. Foster, and J.A. Dearing (Eds), Soil Erosion on Agricultural Lands,* John Wiley, Chichester, 1990, pp. 461-464.

[6] UNEP, In: *Thomas, D.S.G., Middleton, N.J., (Eds), "World Atlas of Desertification,"* UNEP of United Nations Environment Program. Arnold, London, 1997, pp. 182.

[7] H. Dregen, M. Kassas, B. Razanov, "A new assessment of the world status of desertification," *Desertification Control Bulletin,* vol. 20, pp. 6-18, 1991 .

[8] J. M. Tisdall, J. M. Oades, "Organic matter and water-stable aggregates in soils," *Journal of Soil Science,* vol. 33, pp. 141-163, 1982.

[9] W. S. Chepil, "Field structure of cultivated soils with special reference to erodibility by wind," *Soil Science Society of American Proceedings, 17*, *USA,* 1953, pp. 185-190.

[10] W. S. Chepil, "Soil conditions that influence wind erosion," *USDA Technical Bulletin 1185*, pp. 26-28, 1958.

[11] K. E. Saxton, D. Chandler, W. Schillinger, "Wind erosion and air quality research in the Northwest US Columbia Plateua: Organization and Progress," In *D.E. Stott and R.H. Mohtar, and G.C. Steinhardt (eds), Sustaining the Global Farm*, Selected Papers for the 10th International Soil Conservation Organization Meeting May 1999. USDA-ARS National Soil Erosion Research, 2001, pp. 766-770.

[12] F. R. Toreh, J. A. Hobbs, R. L. Donahue, "Soil and water conservation for productivity and environment protection," Printice-Hall, Englewood Cliffs, New Jersey, pp. 1-718, 1980.

[13] B. Diouf, E. L. Skidmore, J. B. Layton, L. J. Hagen, "Stabilizing fine sand by adding clay: Laboratory Wind Tunnel Study," *Soil Technology*, vol. 3, pp. 21-31, 1990.

[14] S. M. Forter, "Microbial aggregation of sand in an embryo dune system," Department of Biological Science, University of Dundee, Dundee, UK, 1979.

[15] E. L. Skidmore, F. H. Siddoway, "Crop residue requirements to control wind erosion," In: *W.R. Oschwald (ed.)*, *Crop Residue Management Systems*, American Society of Agronomy Speciese 31, 1978, pp. 17-33.

[16] L. Abbott. Djajadi, C. Hinz, "Synergistic impact of clay and organic matter on structural and biological properties of sandy soil," *Geoderma*, vol. 183-184, pp. 19-24, 2012.

[17] J. Eldridge, R. Green, "Microbiotic soil crusts: A review of their roles in soil and ecological processes in the rangelands of Australia," *Australian Journal of Soil Research,* vol. 32, pp. 389-415, 1994.

[18] D. V. Armbrust, I. Lyles, *Soil stabilizers to control wind erosion*. In: *W.C. Moldenhauer (ed.)*, American Soil Science Society Spec. 7, Madison, Wisconsin, 1975, pp. 77-82.

[19] A. sharma, T. R. Rao, "Kinetic of pyrolysis of rice husk," *Bioresource Technology*, vol. 67, no. 1, pp. 53-59, 1999.

[20] T. Nakano, "Mechanism of thermopasticity for chemically modified wood," *Hlozforschung* , vol. 48, pp. 318-324, 1994.

[21] C. H. Chio, A. P. Mathews, "Two-steps acid hydrolysis process kinetics in sacharification of low-grade biomass: Experimental studies on the the formation and degradation of sugars," *Bioresource Technology,* vol. 58, pp. 101-106, 1996.

[22] T. Yamada, H. Ono, "Rapid liquefaction of lignocellulosic waste by using ethylene carbonate," *Bioresource Technology,* vol. 70, pp. 61-67, 1999.

[23] Y. Kurimoto, S. Doi, Y. Tamura, "Specific effects on wood liquefaction in polyhydric alcohols," *Holzforschung,* vol. 53, pp. 617-622, 1999.

[24] W. R. Livinston, *Biomass ash characteristics and behavior in combustion, gasification and pyrolysis systems*, **Final draft report, Technology and Engineering, Doosan Babcock Energy, Report NO. 34/07/005, project/subproject 78541/SD001, 2007, pp. 50-69.**

[25] **F. Yu, Y. Liu, X. Pan, X. Lin, C. Liu, P. Chen, R. Ruan, "Liquefaction of corn stover and preparation of polyester from liquefied polyol,"** *Applied Biochemistry Biotechnology*, **Humana Press Inc. 2006, pp. 129-132.**

[26] **Y. Lu, L. Tighzer, P. Dole, D. Erre, "Preparation and properties of starch thermoplastics modified with waterborne polyurethatne from renewable resources,"** *Polymer*, **vol. 46, pp. 9863-9870, 2005.**

[27] **T. Wang, D. Li, L. Wang, J. Yin, X. Chen, Z. Mao, "Effects of CS/EC ratios on structure and properties of polyurethane foams prepared from untreated liquefied corn stover with PAPI,"** *Chemical Engineering Research and Design*, **vol. 86, pp. 416-421, 2008 .**

[28] **Z. Meng, B. Lu, "Dust events as a risk factor for daily hospitalization for respiratory and cardiovascular diseases in Minqin, China,"** *Atmospheric Environment*, **vol. 41, pp. 7048-7058, 2007.**

[29] **M. Metwally, R. Williams,.** *Development of non-petroleum based binders for use in flexible pavements*, **Institute for Transportation, Iowa State University, Final Report, 2010, pp. 1-180.**

[30] **Y. Kurimoto, M. Takeda, A. Koizumi, S. Yamauchi, S. Doi, Y. Tamura, "Mechanical properties of polyurethane films prepared from liquefied wood polymeric MDI,"** *Bioresource Technology*, **vol. 74, pp. 151-157, 2000.**

[31] **Y. Yan, M. Hu, Z. Wang, "Kinetic study on the liquefaction of cornstalk in polyhydric alcohols,"** *Industrial Crops and Products*, **vol. 32, pp. 349-352, 2010 .**

[32] **G. W. Gee, J. W. Bauder, "Particle size analysis," In: A. Klute (ed.)** *Methods of Soil Analysis*, **part 1, 2nd ed. Agronomy Monogram 9. ASA and SSSA, Madison, W 1, 1986, pp. 383-411.**

[33] **B. Craze,** *Soil survey standard test method for soil moisture content,* **Laboratory Procedure, 1990, pp. 2-5.**

[34] **GTM,** *Test method for determination of pH value of water or soil: Geotechnical Test Method*, **State of New York, Department of Transpotation, Geotechnical Engineering Bureau, 2007, pp. 4-5.**

[35] **Y. Wang et al., J. Wu, Y. Wan, H. Lei, F. Yu, P. Chen, X. Lin, Y. Liu, R. Ruan, "Liquefaction of corn stover using industrial glycerol,"** *Agriculture and Biological Engineering,* **vol. 2, pp. 32 -39, 2009.**

إستخدام سوائل ستاف الذرة في تثبيت جزيئات الرمل الخشنه والتربة الدقيقة ضد قوة الرياح: دراسة معملية حقلية

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الملخص

تم دراسة قابلية إستخدام سوائل ستاف الذرة في تثبيت رواسب جزيئات رملية خشن (مادة رابطة بيولوجية). تم تسييل مسحوق حطب الذرة في كربونات الإيثيلين في وجود حامض الكبريتيك المخفف. تم تحضير العينات السائلة مع ٤ مستويات من مخاليط EC / CS،(٢٠%، 22.5٪ ، 25٪ ، 30٪ ، وزن / وزن)، مستويين من درجة حرارة التميع (١٤٠˚م ، ١٦٠˚م)، و أوقات تفاعل متباينة (٣٠ ~ ٩٠ دقيقة). نسب بقايا الغير قابلة للذوبان CSLS زادت مع ارتفاع مزيج EC / CS، ودرجة حرارة تفاعل أقل وزمن تفاعل أقصر. في حين أن اللزوجة في CSLS زادت مع ارتفاع خليط EC / CS، درجة حرارة تفاعل أعلى، وزمن تفاعل أطول. تم وضع عينات التربة الرملية الخشنة المعالجة مسبقاً ومجففة بالهواء والمغطاة بنظام CSLS في نفق خضع لسرعة رياح تتراوح من ٦ م / ث إلى ١٨ م / ث. يمكن للقشور المطورة مع CSLS على سطح التربة الرملية الخشنة أن تتحمل سرعات الرياح حتى ١٠ م / ث، أعلى من هذه السرعة لوحظ تشوه القشرة مع زيادة تدريجية في معدل التعرية. خلص العمل الحالي إلى أن القوى اللاصقة لجميع عينات CSLS لها نفس تأثيرات المقاومة لتدفق الرياح بغض النظر عن ظروف التحضير (نسب EC / CS ، درجة حرارة التفاعل ووقت التفاعل) واللزوجة. كما أظهرت القشرة المطورة على عينات التربة الرملية الخشنة مقاومة عالية لتآكل الرياح إلى سرعة رياح محدودة ؛ ومع ذلك ، وبعد هذا الحد ، لم تعد جزيئات التربة الرملية الخشنة مستقرة.