ONLINE ISSN 2069-7430
ISSN-L 1841-4737
PRO LIGNO
www.proligno.ro
Vol. 10 N° 1 2014
pp. 3-9

INFLUENCE OF IMPACT MODIFIER AND COUPLING AGENT ON IMPACT STRENGTH OF WOOD FLOUR / RECYCLED PLASTIC COMPOSITES

Saman GHAHRI
PhD Student in Wood Based Composites –TARBIAT MODARES University
Address: Department of Wood & Paper Science & Technology, Faculty of Natural Resources, Imam Reza Bd, Nour, Iran
E-mail: Saman_Ghahri@yahoo.com

Saeed KAZEMI NAJAFI
Associate Prof. – TARBIAT MODARES University
Address: Department of Wood & Paper Science & Technology, Faculty of Natural Resources, Imam Reza Bd, Nour, Iran
E-mail: skazemi@modares.ac.ir

Behbood MOHEBBY
Associate Prof. – TARBIAT MODARES University —
Address: Department of Wood & Paper Science & Technology, Faculty of Natural Resources, Imam Reza Bd, Nour, Iran
E-mail: mohebbyb@modares.ac.ir

Abstract:

In this research, the improvement of impact strength of wood flour/recycled polypropylene (PP) composites was investigated. The PP (virgin and recycled polypropylene) and wood flour (WF) were compounded at 50% by weight wood flour loading in a counter-rotating twin-screw extruder in the presence MAPP and two types of impact modifiers (ethylene vinyl acetate (EVA) and ethylene/propylene/diene terpolymer (EPDM)), to produce wood flour-PP composites specimen. The results showed that the composites containing recycled PP exhibited significantly lower impact strength values than those of containing virgin PP. The addition of MAPP, EVA and EPDM in the specimens increased their impact strength. In the presence of MAPP, higher increase in impact strength of the recycled PP/WF composites was observed due to impact modifiers. Both impact modifiers increased the impact strength of the PP/WF composites but the addition of EVA gave the greatest improvements in impact strength. Although the addition of impact modifiers and MAPP increased the impact strength of composites containing recycled PP, such values were still significantly lower than those of containing virgin PP (not modified with MAPP or impact modifier). The use of impact modifiers decreased the flexural properties of the recycled PP/WF composites.

Key words: *thermo-mechanical degradation; impact modifier; coupling agent; recycled polypropylene-wood flour composites.*

INTRODUCTION

The results of previous researches showed that recycling of plastic materials changes the several properties such as melting viscosity, molecular weight, crystallinity, and melting point of plastics (Youngquist *et al*. 1994, Sombatsompop *et al*. 2004, Da Costa *et al*. 2007). These influenced overall mechanical properties of plastics based composites.

Different results were reported for flexural and tensile properties of composites made from recycled plastic in comparison to those made from virgin plastics. Some of these researches indicated similar properties for composites made from virgin and recycled plastics (Selke and Wichman 2004, Kazemi Najafi *et al*. 2006, Adhikary *et al*. 2008), some of them showed superior properties (Mali *et al*. 2003, Kamdem *et al*. 2004, Kazemi Najafi *et al*. 2009) and the others revealed lower properties (Kamdem 2004).

In spite of flexural and tensile properties, the results of all researches showed lower impact strength of composites made from recycled plastics and lingocellulosic materials in comparison to composites made from virgin plastics (Kamdem *et al*. 2004, Kazemi Najafi *et al*. 2009). Lower impact strength of recycled plastic is responsible the lower impact strength of the WPCs containing recycled plastic. Plastic degradation frequently occurs when a polymer is submitted to a process or service. Degradation usually reduces impact strength of plastics. The decrease in impact strength depends on type and level of degradation. Kazemi Najafi *et al*. 2009 showed that the thermo-mechanical degradation during two time extrusion greatly decreases the impact strength of polypropylene and resulted WPCs.

One of the methods to improve impact strength of wood plastic composites is to use impact modifier (IM), and addition of elastomer to plastic (Ghahri *et al*. 2012). Many elastomers have been used as impact modifiers for PP and filled/reinforced PP systems such as WPCs (Oksman and Clemons 1998, Tasdemir and Yıldırım 2002, Farahmand *et al*. 2003, Hristov *et al*. 2004, Oksuz and Eroglu 2005, Feng *et al*. 2006). These elastomers are: ethylene/propylene copolymers (EPM) or ethylene/propylene/diene terpolymer (EPDM) styrene/butadiene/ styrene rubber (SBS), styrene-ethylene/ butylene-styrene (SEBS), SEBS-g-MAH acrylonitrile/butadiene rubber (NBR), ethylene vinyl acetate (EVA), chlorinated polyethylene (CPE), polyisobutylene (PIB), ethylene-propylene rubber(EPM), styrene/butadiene/rubber (SBR), maleic anhydride grafted EPDM, maleic anhydride grafted SEBS. Although, the impact modifiers have a positive effect on increasing impact strength, the negative effect of them on other mechanical properties must be considered.

Regarding to lower impact strength of WPCS made from recycled plastics (especially multi-degraded), the aim of this study is to investigate the improvement of impact strength of wood flour/recycled polypropylene composites by using EVA and EPDM as effective impact modifiers and coupling agent.

Although EVA and EPDM have been successfully used to improve impact properties in virgin plastic composites, no information on its effectiveness for recycled plastics is currently available.

MATERIAL AND METHODS

Raw materials

The PP with grade SI080 was supplied from Polynar Co. Tabriz, Iran). Maleated polypropylene (MAPP) produced by Kimia Javid Inc Isfahan, Iran with a melt flow index (MFI) 100g/10min (T=230ºC, load=2.16kg) and 1.1 percent coupled maleic anhydride was used as compatibilizer. The Ethylene vinyl acetate (EVA) (thermoplastic elastomer) supplied by LG Co. (Daesan petrochemical, South Korea) and ethylene-propylene-diene terpolymer (EPDM) supplied by BAYER Co. (Germany) was used as impact modifiers. Wood flour was obtained by screening industrial sawdust of Iranian beech (*Fagus orientalis*) collected from local mills to +60/-40 mesh particle size. The wood flour was dried in an oven for 24h at 80ºC.

The virgin PP supplied by the company was thermo-mechanically degraded under controlled conditions in a twin-screw extruder at a screw speed of 100 rpm and a temperature of 190ºC. The virgin PP was designated VPP, and R2PP and R5PP represent PP extruded two and five times, respectively.

Panel Manufacturing and Testing

The PP (virgin and recycled polypropylene in 2nd and 5nd cycles) and wood flour were compounded at 50% (W/W) wood flour loading in a counter-rotating twin-screw extruder in presence of different impact modifiers (EVA and EPDM) at 6% (W/W) and MAPP 2% (W/W) to produce wood flour-PP composites.

Flexural modulus and strength of wood flour/recycled polypropylene composites were determined according to ASTM D 7031-04 specification. At least five replicates of each formulation were tested using a computer-controlled DARTEC machine. The speed of the crosshead was set at 5mm/min.

Un-notched impact tests were carried out according to ASTM D 256-90 specification using an Izod testing machine (Santam Co., Iran).

RESULTS AND DISCUSSIONS

The effect of thermo-mechanically degradation of PP on impact strength of wood flour/PP composites is shown in Fig. 1. As can be clearly seen, Impact strength of the PP decrease with increased in the number of extrusion cycles. Duncan's multiple range test results show that the impact strength of R5PP is significantly lower than R2PP. Decrease in molecular weight of degraded PP leads to decrease in impact strength (Narasimha Murathy 2005).

ONLINE ISSN 2069-7430
ISSN-L 1841-4737
PRO LIGNO
www.proligno.ro
Vol. 10 N° 1 2014
pp. 3-9

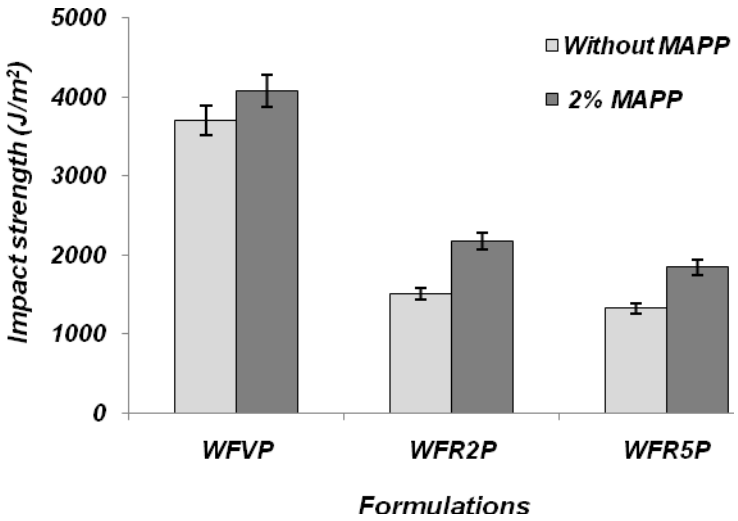

Fig. 1
Effect of thermo-mechanically degradation of PP on impact strength.

Figs. 2 and 3 illustrate the effect of MAPP and impact modifiers type on impact strength of wood flour/ PP composites. With the addition of impact modifier, impact strength significantly increased. Also it can be seen that adding 2% MAPP increased the impact strength of composites. Poor adhesion between the PP matrix and wood flours causes weak mechanical properties of wood plastic composites MAPP improve adhesion between the matrix and wood flours, leading to increased impact strength. Both the impact and interfacial modifiers have significant toughening function on the unmodified PP/wood fiber composites as expressed by large enhancement of the total fracture energy of the modified composites. Maleated polypropylene mainly influenced the crack initiation stage and elastic part of the energy. The impact modifier had more pronounced effect on the crack propagation phase and plastic energy as a result of optimal interfacial bond between the matrix and fibers (Hristov *et al*. 2004). The impact strength of composites containing R2PP and R5PP modified with EVA are more than composites modified with EPDM.

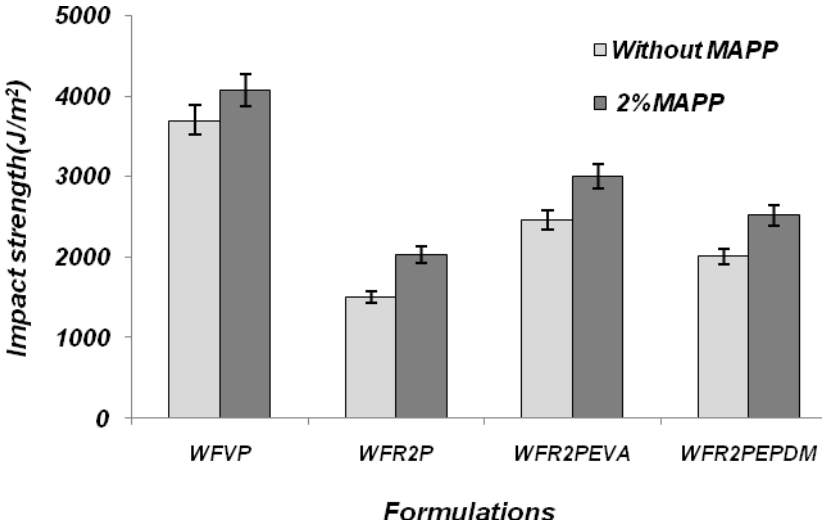

Fig. 2
Effect of MAPP and impact modifiers on impact strength of composites made of two times extruded PP (codes similar to Fig. 1).

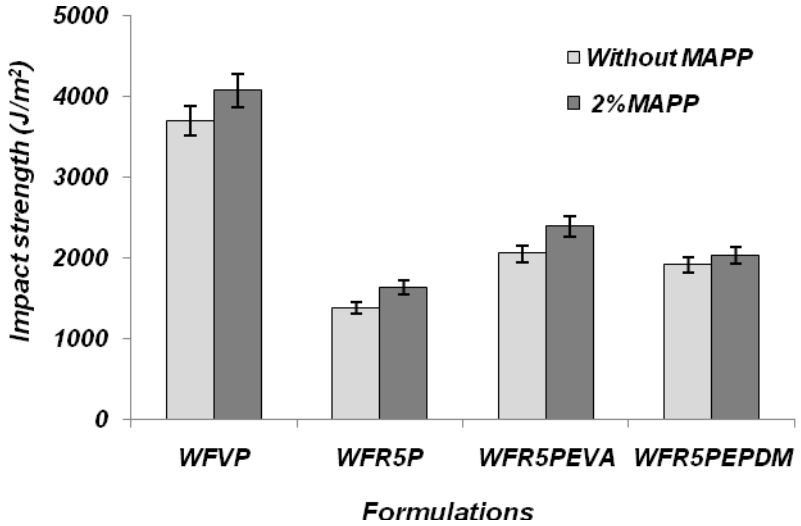

Fig. 3
Effect of MAPP and impact modifiers on impact strength of composites made of five times extruded PP (cods similar to Fig. 1).

Figs. 4 and 5 indicate the effect of impact modifier type on flexural modulus of wood plastic composites. Both impact modifiers reduced flexural modulus of wood plastic composites significantly. This phenomenon was caused by structural characteristics of impact modifier, that is, low modulus of elasticity and weak adhesion between impact modifiers and the PP matrix (Ghahri *et al*. 2012). MAPP coupling agent creates a strong and effective interface between the polar wood flour and non-polar plastic materials and optimizes the Stress transfer from matrix to lingo cellulosic filler, so using MAPP improves this property.

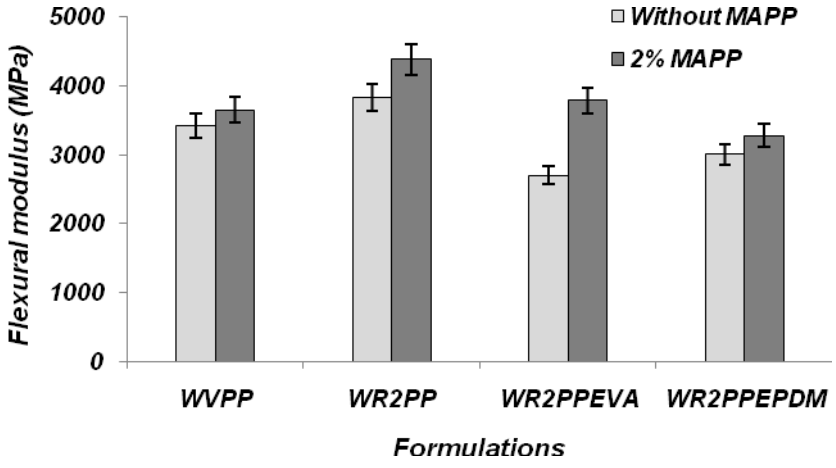

Fig. 4
Effect of MAPP and impact modifiers on flexural modulus of composites made of two times extruded PP (codes similar to Fig. 1).

ONLINE ISSN 2069-7430
ISSN-L 1841-4737
PRO LIGNO
www.proligno.ro
Vol. 10 N° 1 2014
pp. 3-9

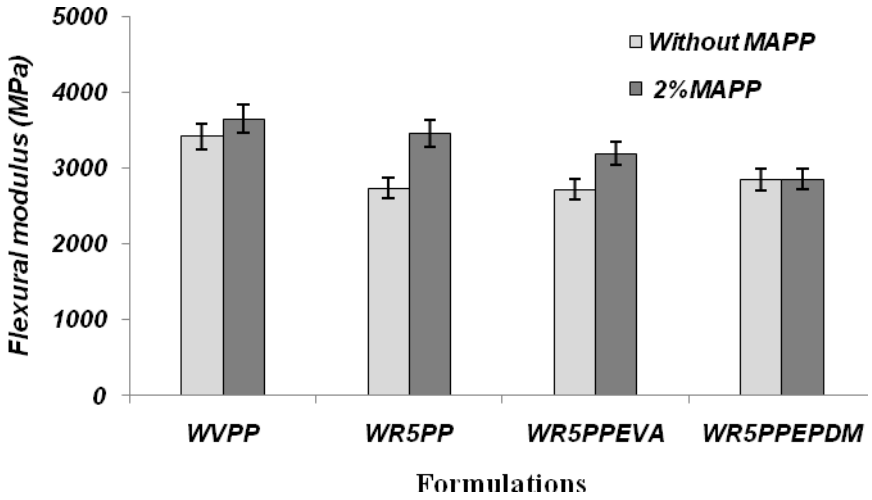

Fig. 5
Effect of MAPP and impact modifiers on flexural modulus of composites made of five times extruded PP (codes similar to Fig. 1).

The effects of impact modifier type and MAPP on Flexural strength of composites are shown in Fig. 6 and 7. The results showed that both impact modifiers reduce the Flexural strength of wood recycled plastic composites. The reason for the decrease in the flexural strength of the composites can be related to the structure of the impact modifier such as low flexural strength (Sheng *et al*. 2008, Tochacek *et al.* 2008). The flexural strength of composites containing MAPP is significantly higher than those without MAPP.

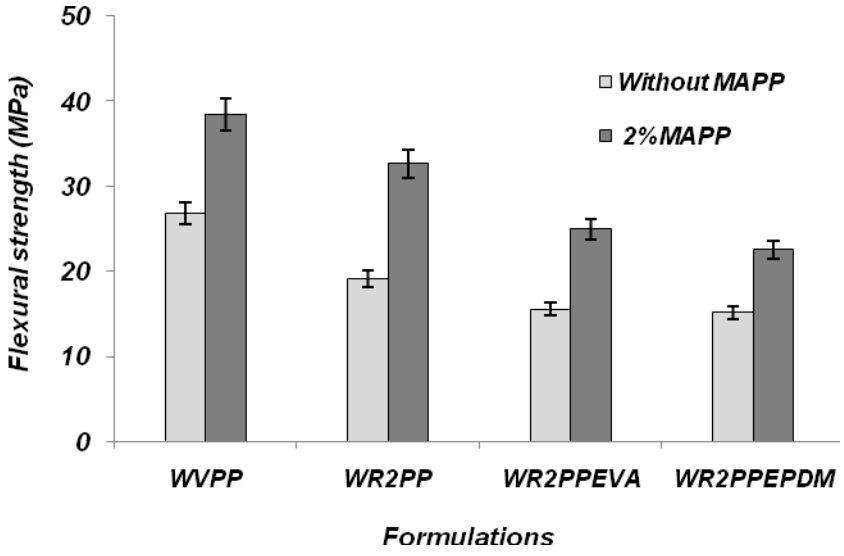

Fig 6.
Effect of MAPP and impact modifiers on flexural strength of composites made of two times extruded PP (codes similar to Fig. 1).

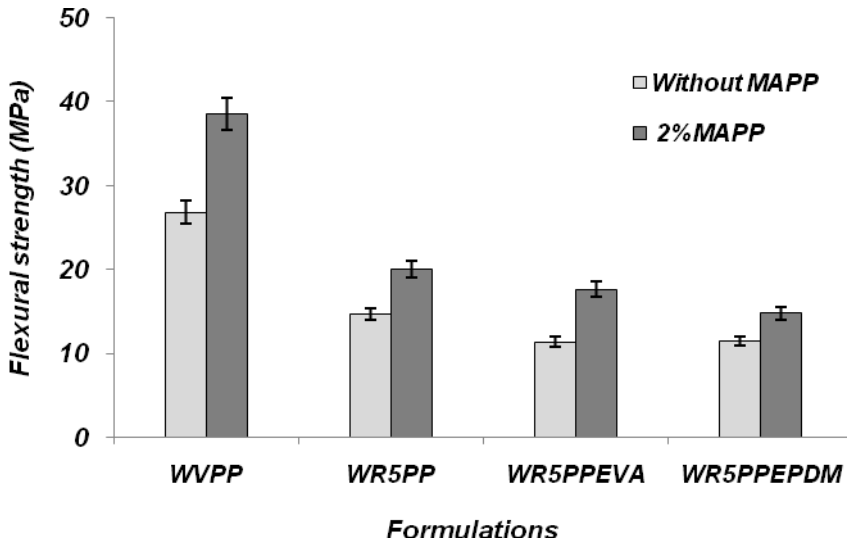

Fig. 7
Effect of MAPP and impact modifiers on flexural strength of composites made of five times extruded PP (codes similar to Fig. 1).

CONCLUSIONS

The effects of Impact Modifier and Coupling Agent on Impact Strength of Wood Flour/Recycled Polypropylene Composites were studied in this research. The following conclusions can be drawn from the results of this work.

- Composites containing recycled PP exhibited significantly lower impact strengths than those containing VPP.
- Impact strength of composites containing recycled PP was improved by using MAPP and impact modifiers.
- Impact modifiers decreased flexural properties of wood flour-recycled PP composites.
- The improved impact strengths of wood flour-recycled PP composites were still significantly lower than those containing VPP (not modified with MAPP or impact modifier).

REFERENCES

Adhikary KB, Pang Sh, Staiger MP (2008) Dimensional stability and mechanical behavior of wood–plastic composites based on recycled and virgin high-density polyethylene (HDPE), Composites, Part B 39:807–815.

American Society for Testing and Material (2004) Evaluating Mechanical and physical properties of wood-plastic Composite ASTM D 7031-04, West Conshohocken, PA, USA.

American Society for Testing and Material (1990) ASTM D256-90b, West Conshohocken, Pa. USA.

Da Costa HM, Ramos VD, Oliveira MG (2007) Degradation of polypropylene (PP) during multiple extrusions: Thermal analysis, mechanical properties and analysis of variance, Polymer Testing 26:674-684.

Farahmand F, Shokrollahi P, Mehrabzadeh M (2003) Recycling of commingled Plastic Waste Containing Polyvinilcholoride, Polypropylene, Polyethylene, and Paper, Iranian Polymer Journal, 12(3):185-190.

Feng J, Te-fu Q (2006) Toughening wood/polypropylene composites with polyethylene octane Elastomer (POE), Journal of Forestry Research, 17(4):312−314.

Ghahri S, Kazemi Najafi S, Mohebby B, Tajvidi M (2012) Impact strength improvement of Wood Flour-Recycled Polypropylene Composites, Journal of Applied Polymer Science, Vol. 124:1074–1080.

Hristov VN, Lach R, Grellmann W (2004) Impact fracture behavior of modified polypropylene/wood fiber

composites, Polymer Testing, 23:581–589.

Kamdem DP, Jiang H, Cui W, Freed J, Matuana LM (2004) Properties of wood plastic composites made of recycled HDPE and wood flour from CCA-treated wood removed from service. Composites, Part A 35:347–355.

Kazemi Najafi S, Hamidinia E, Tajvidi M (2006) Mechanical properties of composites from sawdust and recycled plastics, Journal of Applied Polymer Science 100:3641–3645.

Kazemi Najafi S, Mostafazadeh-Marznaaki M, Chaharmahali M, Tajvidi M (2009) Effect of Thermomehcanical Degradation of Polypropylene on Mechanical properties of Wood-Polypropylene Composites. Journal of Composite Material. 43:2543-2554.

Mali J, Sarsama P, Lindberg LS, Peltonen J, Vilkki M, Koto T, Tiisala S (2003) Wood Fiber plastic Composites, A Research Report Published 31.12.2003 by VTT Technical Research Centre of Finland. Available at: http://www.vtt.fi/rte/uutta/wpc_final_report.pdf

Narasimha Murathy N (2005) Development of Commercial Application for Recycled Plastics Using Finite Element Analysis, Master Degree Thesis, Brigham Young University.

Oksman K, Clemons C (1998) Mechanical Properties and Morphology of Impact Modified Polypropylene-Wood Flour Composites, Applied Polymer Science, 67:1503-1513.

Oksuz M, Eroglu M (2005) Effect of the Elastomer Type on the Microstructure and Mechanical Properties of Polypropylene, Journal of Applied Polymer Science, Vol. 98:1445–1450.

Perkins WG (1999) Polym Eng Sci 39:2445.

Selke SE, Wichman I (2004) Compos Part A: Appl Sci Manufact 35:321–326.

Sheng BR, Li B, Xie BH, Yang W, Feng JM, Yang MB (2008) Influences of molecular weight and crystalline structure on fracture behavior of controlled-rheology-polypropylene prepared by reactive extrusion, Polymer Degradation and Stability, 93:225-232.

Sombatsompop N, Yotinwattanakumtorn C, Thong pin C (2005) Influence of Type and Concentration of Maleic Anhydride Grafted Polypropylene and Impact Modifiers on Mechanical Properties of PP/Wood Wood fluor Composites, Journal of Applied Polymer Science, Vol. 97:475-484.

Tasdemir M, Yıldırım H (2002) JAppl Polym Sci 83:2967.

Tochacek J, Janca´r J, Kalfus J, Zborˇilova´ P, Bura´nˇ Z (2008) Degradation of polypropylene impact-copolymer during processing, Polymer Degradation and Stability, 93:770-775.

Youngquist JA, Myers GE, Muehl JH, Krzysik AM, Clemens CM (1994) Composites from recycled wood and plastics. USDA Forest Service, Forest Product Laboratory, Madison, W53705–2398.