

ND ENERGY STUDENT RESEARCH FELLOWSHIP FINAL REPORT

STUDENT NAME:	Michael Brennan
FACULTY ADVISOR:	Masaru Kuno
REPORT PERIOD:	January 2019 to December 2019
PROJECT TITLE:	Universal Size-Dependent Stokes Shifts in CsPbX ₃ (X=Cl,Br,I) Nanocrystals
CONNECTION TO ND ENERGY'S RESEARCH AREAS (CHECK ALL THAT APPLY):	<input checked="" type="checkbox"/> Energy Conversion and Efficiency <input type="checkbox"/> Sustainable and Secure Nuclear <input type="checkbox"/> Smart Storage and Distribution <input type="checkbox"/> Transformation Solar <input type="checkbox"/> Sustainable Bio/Fossil Fuels <input type="checkbox"/> Transformative Wind

MAJOR GOALS AND ACCOMPLISHMENTS:

List your major research goals and provide a brief description of your accomplishments (1-2 sentences). Indicate the percentage completed for each goal. Please use a separate sheet to share additional details, technical results, charts, and graphics.

MAJOR RESEARCH GOALS	ACTUAL PERFORMANCE AND ACCOMPLISHMENTS	% OF GOAL COMPLETED
Show experimentally size-dependent Stokes shifts exist in CsPbX ₃ nanocrystals.	Size-series of nanocrystals synthesized/fully characterized. Size-dependent Stokes shift have been found to be universal to perovskite nanomaterials. Additionally, the shift is demonstrated to be intrinsic to the nanocrystals electronic structure via single nanocrystal measurements.	100%
Explain the origin of size-dependent Stokes shifts exist in CsPbX ₃ nanocrystals.	Collaborations with a research group at North Dakota State University in progress.	75%
Publish results in peer-reviewed journal.	Manuscript is written and will be completed/submitted when our collaborators at North Dakota finish their calculations.	75%

RESEARCH OUTPUT:

Please provide detailed information below regarding any output resulting from your research project.

CATEGORY	INFORMATION
EXTERNAL PROPOSALS	N/A
EXTERNAL AWARDS	N/A
JOURNAL ARTICLES	<ul style="list-style-type: none"> Brennan, M. C.; et al. Universal Size-Dependent Stokes Shifts in Lead Halide Perovskite Nanocrystals. (<i>In preparation.</i>) Brennan, M. C.; Ruth, A.; Pavlovetc, I. M.; Draguta, S.; Janko, B.; Luther, J. M.; Kuno, M. Suppressing Cation Migration in Hybrid Perovskite Solar Cells. (<i>In preparation</i>) Peli, S.; Brennan, M.C.; Kuno, M.; Banfi, F. Material and Optical Constants for Mixed Halide Perovskite Single Crystals. (<i>In preparation.</i>) Brennan, M.C.; Ruth, A.; Kamat, P.V.; Kuno, M. What Exactly Causes Light-Induced Halide Segregation in Mixed Halide Perovskites? <i>Trends in Chemistry</i> (submitted: December 15th 2019, currently under review). Kuno, M; Brennan, M.C. What Exactly Causes Light-Induced Halide Segregation in Mixed Halide Perovskites? (submitted) Brennan, M. C.; Kuno, M.; Rouvimov, S. Crystal Structure of Individual CsPbBr₃ Perovskite Nanocrystals. <i>Inorg. Chem.</i> 2019, <i>58</i>, 1555-1560.
BOOKS AND CHAPTERS	N/A
PUBLIC PRESENTATIONS, SEMINARS, LECTURES	Brennan, M. C. ; Kuno, M.; Rouvimov, S. Crystal Structure of Individual CsPbBr ₃ Perovskite Nanocrystals. <i>Midwest Imaging and Microanalysis Workshop. 2019</i> Brennan, M. C. ; Kuno, M. Universal Size-Dependent Stokes Shifts in CsPbX ₃ Nanocrystals. <i>PINDU Inorganic Chemistry Symposium 2019, 255.</i>
AWARDS, PRIZES, RECOGNITIONS	Best Electron Microscopy Imaging Publication Award from the ND Integrated Imaging Facility, June 2019.
INTERNAL COLLABORATIONS FOSTERED	John Parkhill/John Herr/Kevin Koh, University of Notre Dame (Department of Chemistry and Biochemistry), first principles modeling of CsPbX ₃ nanocrystal's size-dependent electronic structure.
EXTERNAL COLLABORATIONS FOSTERED	<ul style="list-style-type: none"> Dmitri Kilin/Aaron Forde, North Dakota State University (Department of Chemistry and Biochemistry), model of CsPbX₃ nanocrystal's size-dependent electronic structure and Stokes shift.
WEBSITE(S) FEATURING RESEARCH PROJECT	N/A
OTHER PRODUCTS AND SERVICES (e.g., media reports, databases, software, models, curricula, instruments, education programs, outreach for ND Energy and other groups)	President: Mendoza Energy and Resources Club

MAJOR GOALS AND ACCOMPLISHMENTS
(Additional Details, Technical Results, Charts and Graphics)