Deliverable No: 3

| RGC Reference Project No.: HKUST2/CRF/10 |
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| *please insert ref. above* |

# The Research Grants Council of Hong Kong
# Collaborative Research Fund Group Research Projects
# Completion Report

*(for completed projects only)*

## Part A: The Project and Investigator(s)

### 1. Project Title

Development of Efficient Luminogenic Materials in the Aggregate State: Fundamental Understanding and Practical Applications

### 2. Investigator(s) and Academic Department/Units Involved

| Research Team | Name/Post | Unit/Department/Institution |
|---|---|---|
| Project Coordinator | Prof. Tang, Ben Zhong | Dept. Chemistry/HKUST |
| Co-investigator(s) | Prof. Yam, Vivian W. W.<br>Prof. Wong, Wai-Yeung<br>Prof. Kwok, Hoi Sing<br><br>Prof. Lin, Nian<br>Prof. Wong, Kam Sing<br>Prof. Huang, Xuhui | Dept. Chemistry/HKU<br>Dept. Chemistry/HKBU<br>Dept. Electronic and Computer Engineering/HKUST<br>Dept. Physics/HKUST<br>Dept. Physics/HKUST<br>Dept. Chemistry/HKUST |
| Others | N/A | N/A |

### 3. Project Duration

| | Original | Revised | Date of RGC Approval *(must be quoted)* |
|---|---|---|---|
| Project Start Date | 01 Apr 2011 | N/A | N/A |
| Project Completion Date | 31 Mar 2014 | N/A | N/A |
| Duration *(in month)* | 36 | N/A | N/A |
| Deadline for Submission of Completion Report | 31 Dec 2014 | N/A | N/A |

**CRF 8G** (Revised Dec 08)

**Part B: The Final Report**

## 5. Project Objectives

5.1 Objectives as per original application

1. To assemble an interdisciplinary and multi-institutional collaboration team for the development of efficient luminogenic materials in the aggregate state;
2. To generate, through synergism of innovative material design and synthesis, new luminogens with aggregation-induced emission (AIE) characteristics;
3. To decipher the working principle for the novel photophysical process of AIE;
4. To explore technological applications of the new AIE materials in the areas of optoelectronics and biotechnology.

5.2 Revised objectives

No revision was made

Date of approval from the RGC: _____

Reasons for the change: _____

_____

*1.*
*2.*
*3. ....*

## 6. Research Outcome

6.1 Major findings and research outcome
*(maximum 1 page; please make reference to Part C where necessary)*

In this proposal, we have discovered a novel AIE phenomenon in a series of propeller-shaped molecules such as siloles and tetraphenylethenes and polymers with such units. Instead of quenching, aggregate formation has induced or enhanced the light emission of AIE luminophores. We have proposed that the restriction of intramolecular motion (RIM) accounts for the AIE effect and on the basis of mechanistic understanding, an array of new AIE luminogens with emission color covering the entire visible spectral region and luminescence efficiency up to unity has been developed. We have explored the potential applications of AIE luminogens as chemical sensors, biological probes, smart nanomaterials, and solid-state emitters.

The conceptualization of AIE has changed people's view on light-emitting process in the aggregated state and has attracted much interest among scientists. Hundreds of research groups in the world are now conducting AIE research, as evidenced by the large number of citations (>6500) on the theme of AIE in the year 2013 alone. The research team of Prof. Tang has earned its

reputation as pioneer of AIE research in the scientific community and the mechanism of "restriction of intramolecular motion" proposed by Prof. Tang has been frequently utilized by other scientists to decipher the AIE phenomena of their systems. The scientific discoveries on AIE have often been highlighted by prestigious news media and the research papers associated with AIE have been illustrated as front cover images of *Acc. Chem. Res.* (ACS), *Adv. Funct. Mater.* (Wiley), *Chem. Commun.* (RSC), *Macromolecules* (ACS), etc. According to Thomson Reuters, AIE study is ranked 3rd in the list of Top 100 "Research Fronts" in the areas of Chemistry and Materials Science in 2013. While aggregation-caused quenching (ACQ) is a common phenomenon observed in most aromatic hydrocarbons and their derivatives, our investigation shows that it is not necessarily true and it can work to our benefit through judicious structural design or molecular engineering. A poor emitter in the solution state may luminesce efficiently in the solid state because of the AIE effect. This helps widen our search avenue for efficient light emitters in the solid state.

The AIE effect permits the use of concentrated solutions of luminogens and their aggregates suspended in aqueous medium for sensing applications. Sensors based on AIE luminogens are more emissive, sensitive and photobleaching-resistant than those fabricated from traditional luminophores with ACQ effect. The turn-on nature of AIE sensors makes them promising for field trials, on-site screening, household testing, etc. To fabricate efficient organic light-emitting diodes (OLEDs), scientists have worked hard to hamper crystal formation because luminophore crystallization is known to quench light emission. The crystallization-induced emission effect of AIE crystals is particularly useful for the development of efficient electroluminescence devices, as demonstrated by the outstanding device performances of OLEDs constructed from AIE luminogens. In principle, the AIE effect can be utilized to do useful work wherever the RIM process is involved, with possibilities limited only by our imagination. We also believe that the AIE phenomenon occurs in many systems and this exciting but insufficiently exploited field is waiting for scientists to carry forward.

As suggested in Part C of this report, we have obtained promising results and published >120 high-quality papers during the project. Most of the papers are published in journal articles with high citation indexes and some are written by invitation. Our work has drawn attention from industrial sectors and led to the seal of License Agreement with a big US company on technology transfer. We are confident that further research in this field will lead to more fruitful result.

6.2 Potential for further development of the research and the proposed course of action
*(maximum half a page)*

Development of efficient light emitters in the solid state has both academic value and practical implication. In this proposal, we have prepared a variety of molecules and polymers with AIE characteristics and deciphered that the restriction of intramolecular motion in the aggregated state is the main cause for the AIE effect. We explored the high-technological applications of AIE luminogens as fluorescent chemosensors, bioprobes, smart nanomaterials and solid-state emitters, and obtained promising results. The ACQ effect was discovered by Förster in 1954 and has been under study for more than half century. The AIE concept was debuted in 2001 and thus much remains to be learned in this young area of research. Although the project is completed, we are still working on the synthesis of new materials. Recently, we have observed efficient organic phosphorescence at room temperature in crystals of some AIE luminogens, which has long been regarded as a ''mission impossible'', as triplet excited states are highly susceptible to the thermally activated molecular motions. Thus, we will place effort to develop such system. Special emphasis

will be put on their structure–property relationships because such information is of academic interest, which guides further molecular design on new compounds with tunable and desirable properties. If we are able to get further support from RGC, we will hire experts to explore further the practical applications of our materials.

6.3 Research collaboration achieved *(please give details on the achievement and its relevant impact)*

Close collaboration is needed in order to achieve the results presented above. For example, Profs. B. Z. Tang, V. W. W. Yam and W.-Y. Wong have worked on the design and synthesis of efficient organic, organometallic and polymeric luminogenic materials in the aggregated state and explored their high-technological applications such as biological probes and markers, explosive sensors, metal sensors and so on. Profs. K. S. Wong and N. Lin used steady-state and time-resolved laser-based spectroscopy and microscopy to study the photophysical parameters of the materials. Prof. Xuhui Huang performed theoretical calculation to complement the experimental studies. Prof. H. S. Kwok fabricated OLEDs from materials synthesized by Profs. B. Z. Tang and W.-Y. Wong. Prof. K. S. Wong studied the circularly polarized luminescence of the AIE luminogens obtained from Prof. B. Z. Tang. As shown in Part C of the report, 24 joint papers (*J. Mat. Chem. C* **2014**, *2*, 78–83; *Chem.–A Eur. J.* **2014**, *20*, 133–138; *Opt. Mater. Express* **2013**, *3*, 1906–1911; *Chem. Commun.* **2013**, *49*, 7216–7218; *J. Mater. Chem. C* **2013**, *1*, 4640–4646; *Chem. Commun.* **2013**, *49*, 594–596.; *Chem. Sci.* **2012**, *3*, 2737; *J. Am. Chem. Soc.* **2012**, *134*, 168; *Adv. Funct. Mater.* **2011**, *21*,3785; *Chem. Commun.* **2011**, *47*, 10073; *Adv. Mater.* **2012**, *24*, 1034; *Adv. Funct. Mater.* **2012**, *22*, 378; *Chem. Sci.* **2012**, *3*, 1804; *Chem. Commun.* **2012**, *48*, 8637; *J. Mater. Chem.* **2012**, *22*, 11018; *Polym. Chem.* **2012**, *3*, 1481; *Chem. Mater.* **2012**, *24*, 1518; *Chem. Asian J.* **2012**, *7*, 484; *J. Mater. Chem.* **2012**, *22*, 5184; *J. Mater. Chem.* **2012**, *22*, 4527; *Chem. Sci.* **2012**, *3*, 549; *Adv. Mater.* **2011**, *23*, 5430; *Chem. Commun.* **2011**, *47*, 11216; *Chem. Commun.* **2010**, *47*, 8847) have been published by the team members.

Prof. V. W. W. Yam has collaborated with Prof. B. Z. Tang and incorporated AIE luminogens as ligands to the platinum(II) complexes. She has also collaborated with Prof. Xuhui Huang to use molecular simulation to study the aggregation behavior of amphiphilic platinum(II) complexes.

We have annual meetings on 25 Aug 2011 and 31 Aug 2012. Prof. W.-Y. Wong met the research groups of Profs. B. Z. Tang and H. S. Kwok regularly to discuss the photophysical measurements of new AIE-active molecules and testing of OLEDs, respectively in HKUST. Collaboration between the team members is also achieved through e-mail correspondences. Prof. Tang, B. Z. has also collaborated with Prof. B. Liu in National University of Singapore to prepare fluorescent nanoparticles from AIE materials for cell imaging and studying biological processes. More than 20 joint papers (e.g. *Acc. Chem. Res.* **2013**, *45*, 2441; *Chem. Commun.* **2014**, *50*, 295; *Nanoscale* **2014**, *6*, 939; *Adv. Mater.* **2013**, *25*, 6083; *Adv. Healthcare Mater.* **2013**, *2*, 1600; *Adv. Funct. Mater.* **2013**, *23*, 635) have been published by Profs. Tang and Liu.

## 7. The Layman's Summary

*(describe in layman's language the nature, significance and value of the research project, in no more than 200 words)*

Development of efficient luminescent materials in the solid state has both academic value and technology implication. Traditional luminophores show bright emission in the solution state but become weakly emissive or even non-luminescent when aggregated. Such aggregation-caused

quenching (ACQ) effect has significantly limited their practical applications. In this investigation, we have discovered a phenomenon of aggregation-induced emission (AIE) that is exactly opposite to the ACQ effect in some propeller-shaped molecules such as hexaphenylsilole and tetraphenylethene. Instead of quenching, aggregate formation has turned them from weak emitters in solution to strong luminophores in the aggregated state. The restriction of intramolecular motion in the aggregated state is the main cause for such phenomenon. Through the mechanistic understanding, we have designed and synthesized AIE luminogens with a great diversity in structure, ranging from pure hydrocarbons, organometallic complexes, small molecules, high molecular weight polymers, and systems with extended $\pi$-conjugation. We have explored their high-technological applications as fluorescent chemosensors (for explosive, ion, pH, temperature, viscosity, pressure, etc.), biological probes (for protein, DNA, RNA, sugar, phospholipid, etc.), smart nanomaterials, solid-state emitters, etc., and obtained promising results.

**CRF 8G** (Revised Dec 08)

**Part C: Research Output**

## 8. Peer-reviewed journal publication(s) arising directly from this research project

*(Please attach a copy of the publication and/or the letter of acceptance if not yet submitted in the previous progress report(s). All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.)*

| The Latest Status of Publications | | | | Author(s) *(denote the corresponding author with an asterisk*)* | Title and Journal/Book *(with the volume, pages and other necessary publishing details specified)* | Submitted to RGC *(indicate the year ending of the relevant progress report)* | Attached to this report *(Yes or No)* | Acknowledged the support of RGC *(Yes or No)* |
|---|---|---|---|---|---|---|---|---|
| Year of publication | Year of Acceptance (For paper accepted but not yet published) | Under Review | Under Preparation (optional) | | | | | |
| 2014 | | | | Tong, J.; Wang, Y.; Mei, J.; Wang, J.; Qin, A.; Sun, J. Z*.; Tang, B. Z* | "A 1,3-Indandione-Functionalized Tetraphenylethene: Aggregation-Induced Emission, Solvatochromism, Mechanochromism, and Potential Application as a Multiresponsive Fluorescent Probe" *Chem. Eur. J.* **2014**, *20*, 4661–4670. | 2014 | Yes | Yes |
| 2014 | | | | Zhao, N; Zhang, C; Lam, J. W. Y.; Zhao, Y. S.; Tang, B. Z* | "An Aggregation-Induced Emission Luminogen with Efficient Luminescent Mechanochromism and Optical Waveguiding Properties" *Asian J. Org. Chem.* **2014**, *3*, 118–121. | 2014 | Yes | Yes |

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| 2014 | | | | Parrott, E. P. J.; Tan, N. Y.; Hu, R. R.; Zeitler, J. A.; Tang, B. Z*.; Pickwell-MacPherson, E* | "Direct Evidence to Support the Restriction of Intramolecular Rotation Hypothesis for the Mechanism of Aggregation-Induced Emission: Temperature Resolved Terahertz Spectra of Tetraphenylethene" *Mater. Horiz.* **2014**, *1*, 251–258. | 2014 | Yes | Yes |
| 2014 | | | | Wang, D*.; Qian, J*.; Qin, W.; Qin, A.; Tang, B. Z. He, S. | "Biocompatible and Photostable AIE Dots with Red Emission for In Vivo Two-Photon Bioimaging" *Scientific Reports* **2014**, *4*, 4279-1–8. | 2014 | Yes | Yes |
| 2014 | | | | Lou, X.; Hong, Y.; Chen, S.; Leung, C. W. T.; Zhao, N.; Situ, B.; Lam, J. W. Y.; Tang, B. Z* | "A Selective Glutathione Probe based on AIE Fluorogen and its Application in Enzymatic Activity Assay" *Scientific Reports* **2014**, *4*, 4272-1–6. | 2014 | Yes | Yes |
| 2014 | | | | Yuan, Y.; Chen, Y.; Tang, B. Z*.; Liu, B* | "A Targeted Theranostic Platinum(IV) Prodrug Containing a Luminogen with | 2014 | Yes | Yes |

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| | | | | | Aggregation-Induced Emission (AIE) Characteristics for in situ Monitoring of Drug Activation" *Chem.Commun.* **2014**, *50*, 3868–3870. | | | |
| 2014 | | | | Wang, E.; Zhao, E.; Hong, Y.; Lam, J. W. Y.; Tang, B. Z* | "A Highly Selective AIE Fluorogen for Lipid Droplet Imaging in Live Cells and Green Algae" *J. Mater. Chem. B* **2014**, *2*, 2013–2019. | 2014 | Yes | Yes |
| 2014 | | | | Zhao, E.; Li, H.; Ling, J.; Wu, H.; Wang, J.; Zhang, S.; Lam, J. W. Y.; Sun, J. Z.; Qin, A*.; Tang, B. Z* | "Structure-Dependent Emission of Polytriazoles" *Poly. Chem.* **2014**, *5*, 2301–2308. | 2014 | Yes | Yes |
| 2014 | | | | Song, Z.; Hong, Y.; Kwok, R. T. K.; Lam, J. W. Y.; Liu, B*.; Tang, B. Z* | "A Dual-Mode Fluorescence "Turn-on" Biosensor Based on an Aggregation-Induced Emission Luminogen" *J. Mater. Chem. B* **2014**, *2*, 1717–1723. | 2014 | Yes | Yes |
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| 2013 | | | | Ding, D.; Li, K.; Liu, B*.; Tang, B. Z* | "Bioprobes Based on AIE Fluorogens" *Acc. Chem. Res.* **2013**, *46*, 2441–2453. | 2014 | No | Yes |
| 2013 | | | | Zhao, Z.; Lam, J. W. Y.; Tang, B. Z* | "Self-assembly of Organic Luminophors with Gelation-Enhanced Emission Characteristics" *Soft Matter* **2013**, *9*, 4564–4579. | 2014 | No | Yes |
| 2014 | | | | Yuan, Y.; Kwok, R. T. K.; Feng, G.; Liang, J.; Geng, J.; Tang, B. Z*.; Liu, B* | "Rational Design of Fluorescent Light-Up Probes Based on an AIE Luminogen for Targeted Intracellular Thiol Imaging" *Chem. Commun.* **2014**, *50*, 295–297. | 2014 | No | Yes |
| 2014 | | | | Ng, J. C. Y.; Liu, J.; Su, H.; Hong, Y.; Li, H.; Lam, J. W. Y.; Wong, K. S.; Tang, B. Z* | "Complexation-Induced Circular Dichroism and Circularly Polarised Luminescence of an Aggregation-Induced Emission Luminogen" *J. Mat. Chem. C* **2014**, *2*, 78–83. | 2014 | No | Yes |

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| 2014 | | | | Geng, J.; Zhu, Z.; Qin, W.; Ma, L.; Hu, Y.; Gurzadyan, G. G.; Tang, B. Z.; Liu, B* | "Near-Infrared Fluorescence Amplified Organic Nanoparticles with Aggregation-Induced Emission Characteristics for in Vivo Imaging" *Nanoscale* **2014**, *6*, 939–945. | 2014 | No | Yes |
| 2014 | | | | Ding, D.; Liang, J.; Shi, H.; Kwok, R. T. K.; Gao, M.; Feng, G.; Yuan, Y.; Tang, B. Z*.; Liu, B* | "Light-up Bioprobe with Aggregation-Induced Emission Characteristics for Real-Time Apoptosis Imaging in Target Cancer Cells" *J. Mat. Chem.* B **2014**, *2*, 231–238. | 2014 | No | Yes |
| 2014 | | | | Liang, G.; Weng, L.-T.; Lam, J. W. Y.; Qin, W.; Tang, B. Z* | "Crystallization-Induced Hybrid Nano-Sheets of Fluorescent Polymers with Aggregation-Induced Emission Characteris | 2014 | No | Yes |

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| | | | | | tics for Sensitive Explosive Detection" *ACS Macro Lett.* **2014**, *3*, 21–25. | | | |
| 2014 | | | | Zhao, N.; Lam, J. W. Y.; Sung, H. H. Y.; Su, H. M.; Williams, I. D.; Wong, K. S.; Tang, B. Z* | "Effect of the Counterion on Light Emission: A Displacement Strategy to Change the Emission Behaviour from Aggregation-Caused Quenching to Aggregation-Induced Emission and to Construct Sensitive Fluorescent Sensors for Hg2+ Detection" *Chem.–A Eur. J.* **2014**, *20*, 133–138. | 2014 | No | Yes |
| 2014 | | | | Zhao, Z*.; He, B.; Nie, H.; Chen, B.; Lu, P.; Qin, A.; Tang, B. Z* | "Stereoselective Synthesis of Folded Luminogens with Arene–Arene Stacking Interactions and Aggregation-Enhanced Emission *Chem. Commun.* **2014**, *50*, | 2014 | NO | Yes |

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| | | | | | 1131–1133. | | | |
| 2014 | | | | Parrott, E. P. J.; Tan, N. Y.; Hu, R. R.; Zeitler, J. A*.; Tang, B. Z*.; Pickwell-MacPherson, E* | "Direct Evidence to Support the Restriction of Intramolecular Rotation Hypothesis for the Mechanism of Aggregation-Induced Emission: Temperature Resolved Terahertz Spectra of Tetraphenylethene" *Mat. Horizons* **2014**, *1*, 252–258 | 2014 | No | Yes |
| 2014 | | | | Leung, C.; Hong, Y.; Hanske, J.; Zhao, E.; Chen, S.; Pletneva, E.; Tang, B. Z* | "Superior Fluorescent Probe for Detection of Cardiolipin" *Anal. Chem.* **2014**, *86*, 1263–1268. | 2014 | No | Yes |
| 2014 | | | | Wang, E.; Lam, J. W. Y.; Hu, R.; Zhang, C.; Zhao, Y.; Tang, B. Z* | "Twisted Intramolecular Charge Transfer, Aggregation-Induced Emission, Supramolecular Self-assembly and Optical | 2014 | No | Yes |

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| | | | | | Waveguide of Barbituric Acid-Functionalized Tetraphenylethene" *J. Mater. Chem. C* **2014**, *2*, 1801–1807 | | | |
| 2014 | | | | Liang, G.; Lam, J. W. Y.; Qin, W.; Li, J.; Xie, N.; Tang, B. Z* | "Molecular Luminogens Based on Restriction of Intramolecular Motions through Host-Guest Inclusion for Cell Imaging" *Chem. Commun.* **2014**, *50*, 1725–1727 | 2014 | No | Yes |
| 2014 | | | | Qin, W.; Li, K.; Feng, G.; Li, M.; Yang, Z.; Liu, B*.; Tang, B. Z* | "Bright and Photostable Organic Fluorescent Dots with Aggregation-Induced Emission Characteristics for Noninvasive Long-term Cell Imaging" *Adv. Funct. Mater.* **2013**, *23*, 635–643 | 2014 | No | Yes |

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|---|---|---|---|---|---|---|---|---|
| 2013 | | | | Zhao, Z*.; Chen, B.; Geng, J.; Chang, Z.; Aparicio-Ixta, L.; Nie, H.; Qin, A.; Ramos-Ortiz, G.; Liu, B*.; Tang, B. Z* | "Red Emissive Biocompatible Nanoparticles from Tetraphenylethene-Decorated BODIPY Luminogens for Two-Photon Excited Fluorescence Cellular Imaging and Mouse Brain Blood Vascular Visualization" *Particle & Particle Systems Characterization* **2013**, *1*, DOI: 10.1002/ppsc.201300223 | 2014 | No | Yes |
| 2013 | | | | Li, Y.; Kwok, R. T. K.; Tang, B. Z*.; Liu, B* | "Specific Nucleic Acid Detection Based on Fluorescent Light-up Probe from Fluorogens with Aggregation-Induced Emission Characteristics" *RSC Advances* **2013**, *3*, 10135–10138. | 2014 | No | Yes |

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| 2013 | | | | Zhao, E.; Hong, Y.; Chen, S.; Leung, C. W. T.; Chan, C. Y. K.; Kwok, R. T. K.; Lam, J. W. Y.; Tang, B. Z* | "Highly Fluorescent and Photostable Probe for Long-Term Bacterial Viability Assay Based on Aggregation-Induced Emission" *Adv. Healthcare Mater.* **2013**, *2*, DOI: 10.1002/adhm.201200475 | 2014 | No | Yes |
| 2013 | | | | Leung, C. W. T.; Hong, Y.; Tang, B. Z* | " Probing Proteins and Differentiating Their Native and Denatured States with Aggregation-Induced Emission Fluorogen" *J. Mol. Eng. Mater.* **2013**, *1*, in press. | 2014 | No | Yes |
| 2013 | | | | Shen, X. Y.; Wang, Y.; Zhao, E.; Yuan, W.; Liu, Y.; Lu, P.; Qin, A.; Ma, Y.; Sun, J*.; Tang, B. Z* | "Effects of Substitution with Donor-Acceptor Groups on the Properties of Tetraphenylethene Trimer: Aggregation-Induced Emission, Solvatochromism, and Mechanochromism" *J.* | 2014 | No | Yes |

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| | | | | | *Phys. Chem.* **2013**, *117*, 7334–7347. | | | |
| 2013 | | | | Wang, Z.; Chen, S.; Lam, J. W. Y.; Qin, W.; Kwok, R. T. K.; Xie, N.; Hu, Q.; Tang, B. Z* | "Long-Term Fluorescent Cellular Tracing by the Aggregates of AIE Bioconjugates" *J. Am. Chem. Soc.* **2013**, *135*, 8238−8245. | 2014 | No | Yes |
| 2013 | | | | Chen, S.; Hong, Y.; Liu, Y.; Liu, J.; Leung, C. W. T.; Li, M.; Kwok, R. T. K.; Zhao, E.; Lam, J. W. Y.; Yu, Y.; Tang, B. Z* | "Full-Range Intracellular pH Sensing by an AIE-Active Two-Channel Ratiometric Fluorogen" *J. Am. Chem. Soc.* **2013**, *135*, 4926–4929. | 2014 | No | Yes |
| 2013 | | | | Leung, C. W. T.; Hong, Y.; Chen, S.; Zhao, E.; Lam, J. W. Y.; Tang, B. Z* | "A Photostable AIE Luminogen for Specific Mitochondrial Imaging and Tracking" *J. Am. Chem. Soc.* **2013**, *135*, 62−65. | 2014 | No | Yes |

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| 2013 | | | | Ding, D.; Goh, C. C.; Feng, G.; Zhao, Z.; Liu, J.; Liu, R.; Tomczak, N.; Geng, J.; Tang, B. Z.; Ng, L. G*.; Liu, B* | "Ultrabright Organic Dots with Aggregation-Induced Emission Characteristics for Real-time Two-Photon Intravital Vasculature Imaging" *Adv. Mater.* **2013**, *25*, 6083–6088. | 2014 | NO | Yes |
| 2013 | | | | Yuan, Y. W.; Tan, Y.; Gong, Y.; Lu, P.; Lam, J. W. Y.; Shen, X. Y.; Feng, C.; Sung, H. H. Y.; Lu, Y.; Williams, I. D.; Sun, J. Z.; Zhang, Y*.; Tang, B. Z* | "Synergy between Twisted Conformation and Effective Intermolecular Interaction: Strategy for Efficient Mechanochromic Luminogens with High Contrast" *Adv. Mater.* **2013**, *25*, 2837–2843. | 2014 | No | Yes |
| 2013 | | | | Li, K*.; Qin, W*.; Ding, D.; Tomczak, N.; Geng, J.; Liu, R.; Liu, J.; Zhang, X.; Liu, H.; Liu, B.; Tang, B. Z | "Photostable Fluorescent Organic Dots with Aggregation-Induced Emission (AIE Dots) for Noninvasive Long-Term Cell Tracing" *Scientific Reports* **2013**, *3*, 1150. | 2014 | NO | Yes |

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| 2013 | | | | Yang, Z.; Qin, W.; Lam, J. W. Y.; Chen, S.; Sung, H. H. M.; Williams, I D.; Tang, B. Z* | "Fluorescent pH Sensor Constructed from a Heteroatom-Containing Luminogen with Tunable AIE and ICT Characteristics" *Chem. Sci.* **2013**, *4*, 3725–3730. | 2014 | No | Yes |
| 2013 | | | | Li, K.; Ding, D.; Prashant, C.; Qin, W.; Yang, C.-T.; Tang, B. Z.; Liu, B* | "Gadolinium-Functionalized Aggregation-Induced Emission Dots as Dual-Modality Probes for Cancer Metastasis Study" *Adv. Healthcare Mater.* **2013**, *2*, 1600–1605. | 2014 | No | Yes |
| 2013 | | | | Yue, Z.; Cheung, Y. F.; Choi, H. W.; Zhao, Z.; Tang, B. Z.; Wong, K. S* | "Hybrid GaN/Organic White Light Emitters with Aggregation Induced Emission Organic Molecule" *Opt. Mater. Express* **2013**, *3*, 1906–1911. | 2014 | No | Yes |

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| 2013 | | | | Li, K; Zhu, Z.; Cai, P.; Liu, R. R.; Tomczak, N.; Ding, D.; Liu, J.; Qin, W.; Zhao, Z.; Hu, Y.; Chen, X.; Tang, B. Z.; Liu, B* | "Organic Dots with Aggregation-Induced Emission (AIE dots) Characteristics for Dual-Color Cell Tracing" *Chem. Mater.* **2013**, *25*, 4181–4187. | 2014 | No | Yes |
| 2013 | | | | Han, T.; Hong, Y.; Xie, N.; Chen, S.; Zhao, N.; Zhao, E.; Lam, J. W. Y.; Sung, H. H. Y.; Dong, Y.; Tong, B.; Tang, B. Z* | "Defect-Sensitive Crystals Based on Diaminomaleonitrile-Functionalized Schiff Base with Aggregation-Enhanced Emission" *J. Mater. Chem. C* **2013**, *1*, 7314–7320. | 2014 | No | Yes |
| 2013 | | | | Shi, H.; Zhao, N.; Ding, D.; Liang, J.; Tang, B. Z*.; Liu, B* | "Fluorescent Light-Up Probe with Aggregation-Induced Emission Characteristics for In Vivo Imaging of Cell Apoptosis" *Org. Biomole. Chem.* **2013**, *11*, 7289–7296. | 2014 | No | Yes |

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| 2013 | | | | Hu, R.; Ye, R.; Lam, J. W. Y.; Li, M.; Leung, C. W. T.; Tang, B. Z* | "Conjugated Polyelectrolytes with Aggregation-Enhanced Emission Characteristics: Synthesis and Their Biological Applications" *Chem.–Asian J.* **2013**, *8*, 2436–2445. | 2014 | No | Yes |
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| 2012 | | | | Xu, X.; Zhao, Y.; Dang, J.; Yang, X.; Zhou, G*.; Ma, D*.; Wang, L.; Wong, W.-Y*.; Wu, Z*.; Zhao, X* | "Simple Tuning of the Optoelectronic Properties of $Ir^{III}$ and $Pt^{II}$ Electrophosphors Based on Linkage Isomer Formation with Naphthylthiazolyl Moiety", | 2012 | No | Yes |

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| 2011 | | | | Hu, Y. C.; Chan, K. H. Y.; Chung, C. Y. S.; Yam, V. W. W*. | "Reversible Thermo-Responsive Luminescent Metallo-Supramolecular Triblock Copolymers Based on Platinum(II) Terpyridyl Chromophores with Unusual Aggregation Behaviour and Red-Near-Infrared (NIR) Emission Upon Heating", *Dalton Transactions*, **2011**, *40*, 12228-12234 (invited article, | 2012 | No | Yes |

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| 2012 | | | | Li, M. J.; Wong, K. M. C.; Yi, C. Q.; Yam, V. W. W*. | "New Ruthenium(II) Complexes Functionalized with Coumarin Derivatives: Synthesis, Energy-Transfer-Based Sensing of Esterase, Cytoxicity, and Imaging Studies", *Chem. Eur. J.*, **2012**, *18*, 8724-8730. | 2012 | No | Yes |
| 2012 | | | | Lam, E. S. H.; Tam, A. Y. Y*.; Lam, W. H*.; Wong, K. M. | Structure, Photophysical Properties and | 2012 | No | Yes |

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| 2012 | 2012 | | | Au, V. K. M.; Zhu, N.; Yam, V. W. W* | "Luminescent Metallogels of Bis-Cyclometalated Alkynylgold(III) Complexes", *Inorg. Chem.*, **2012**, in press. | 2012 | No | Yes |
| 2012 | 2012 | | | Su, H.;, Zhong, Y.; Ming, T.; Wang, J.; Wong, K. S.* | "Extraordinary plasmon-coupled fluorescence on gold nanorods with core/shell configuration", *J. Phys. Chem. C*, **2012**, *116*, 9259 | 2012 | No | Yes |

**CRF 8G** (Revised Dec 08)

**9. Recognized international conference(s) in which paper(s) related to this research project was/were delivered** *(Please attach a copy of each conference abstract)*

| Month/Year/ Place | Title | Conference Name | Submitted to RGC *(indicate the year ending of the relevant progress report)* | Attached to this report *(Yes or No)* | Acknowledged the support of RGC *(Yes or No)* |
|---|---|---|---|---|---|
| Dec/2013/Beijing | "Organic AIEgens for Bioelectronic Applications" | Asian–European Symposium on Organic Optoelectronics | 2014 | Yes | Yes* |
| Oct/2013/Beijing | "Optical Sensors Based on AIE Fluorogens" | The 15th International Beijing Conference and Exhibition on Instrumental Analysis | 2014 | Yes | Yes* |
| Sept/2013/Xi'an | "Biological Probes Based on AIE Fluorogens" | The 14th National Meeting on Biomaterials | 2014 | Yes | Yes* |
| Aug/2013/ Fukuoka, Japan, | "Biological Analysis Based on AIE Fluorogens" | ASIANALYSIS XII, | 2014 | Yes | Yes* |
| Jun/2013/Singapore | "Fluorescent Nanoparticles with Aggregation-Induced Emission Characteristics as Biosensors" | The 7th International Conference on Materials for Advanced Technologies | 2014 | Yes | Yes* |
| May/2013/ Wuhan | "Bioprobes Based on AIE Fluorogens" | The 1st International Symposium on Aggregation-Induced Emission | 2014 | Yes | Yes* |
| Dec/2012/ Nagoya, Japan | "Aggregation-Induced Emission: Fundamentals and Applications" T | The 2nd International Conference on MEXT Project of Integrated Research on Chemical Synthesis, | 2014 | Yes | Yes* |
| November/ 2011/Taiwan | Recent Progress in Phosphorescent White Organic Light-Emitting Devices | Asian Conference on Organic Electronics (A-COE 2011) | 2012 | No | Yes* |
| July/2012/ Paris | Plasmon control emission on fluorophore-doped core/ shell metal nanoparticles | International Conference on Nanoscience + Technology | 2012 | No | Yes |

*The abstract does not contain an acknowledgement section but we have verbally acknowledged support of RGC in the conference.

**10.** ***Student(s) trained*** (please attach a copy of the title page of the thesis)

| Name | Degree registered for | Date of registration | Date of thesis submission/ graduation |
|---|---|---|---|
| Hao Wu | Ph.D. | July 2010 | June 2013 |
| Yilin Zhang | Ph. D | Sept 2010 | July 2015 |
| Wai Tung Leung | Ph.D | Sept 2011 | Aug 2015 |
| Haiqin Dng | Ph.D | Sept 2012 | Aug 2016 |
| Yee Yung Yu | Ph.D | Sept 2012 | Aug 2016 |
| Yueyue Zhao | Ph.D | Sept 2013 | Aug 2017 |
| Lik Ching Leung | Ph.D | Sept 2013 | Aug 2017 |

**11.** **Other impact** *(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, etc.)*

Prof. W.-Y Wong won the "Distinguished Lectureship Award" from "The Chemical Society of Japan" in 2012, in recognition of his outstanding contributions on photofunctional materials chemistry.

1. Journal of Materials Chemistry Blog highlighted our work with B. Tong on "Defect-sensitive crystals based on diaminomaleonitrile-functionalized Schiff base with aggregation-enhanced emission" as one of the Hot Articles for March 2014.
2. Our paper on "Facile Synthesis of Poly(aroxycarbonyltriazole)s with Aggregation-Induced Emission Characteristics by Metal-Free Click Polymerization" was awarded the Best Paper published in *Science China Chemistry* in 2011 (award announced in March 2014).
3. ScienceDaily highlighted our joint work with E. Pletneva of Dartmouth on the development of a new fluorescent probe for detection of cardiolipin (*Analytical Chemistry*, **2013**; *86*, 1263) on 16 Jan 2014.
4. *Materials Views* highlighted our work on the development of Highly Fluorescent and Photostable Probe for Long-Term Bacterial Viability Assay Based on Aggregation-Induced Emission (*Advanced Healthcare Materials* **2014**, *3*, 88) on 16 Jan 2014.
5. Sarah Millar highlighted our work on the development of a displacement strategy for ACQ-to-AIE transforming in *ChemistryViews* on 9 Jan 2014.
6. Our work on defect-sensitive AEE crystals was listed as one of the 2013 *Journal of Materials Chemistry C* Hot Papers.
7. Our work on biotin-decorated fluorescent AIE-active silica nanoparticles for biological applications was listed as one of the 2013 Most Accessed Manuscripts for *Journal of Materials Chemistry B*.
8. Our review article on Self-assembly of organic luminophores with gelation-enhanced emission characteristics has been highlighted as one of the 2013's most accessed Soft Matter articles.
9. Kurzweil Accelerating Intelligence highlighted our joint work with B. Liu on photostable AIE dots for noninvasive long-term cell tracing (*Scientific Reports* **2013**, *3*, 1150) on 3 Sept 2013.
10. *ScienceDaily* highlighted our joint work with B. Liu on photostable AIE dots for noninvasive long-term cell tracing (*Scientific Reports* **2013**, *3*, 1150) on 31 Aug 2013.
11. *Phys.Org* highlighted our joint work with B. Liu on photostable AIE dots for noninvasive long-term cell tracing (*Scientific Reports* **2013**, *3*, 1150) on 14 Aug 2013.
12. Our work on metal-free click polymerization of propiolates and azides published in *Polymer Chemistry* was amongst the Top Ten Most-Read Articles in Q2 of 2013.

13. *Phys.Org* highlighted our joint work with B. Liu on the development of fluorescent indicator for real-time monitoring of cell apoptosis process (*J. Am. Chem. Soc.* **2012**, *134*, 17972) on May 08, 2013.
14. *Chemical Communications* highlighted our joint work with Z. Zhao on AIE-active tetranaphthylethene (**2013**, *49*, 2491) as the inside front cover of its March 28, 2013 issue.
15. *Advanced Healthcare Materials* highlighted our joint work with B. Liu on the conjugated polymer amplified FR/NIR fluorescence from AIE nanoparticles for targeted in vivo imaging (**2013**, *2*, 500) as the inside front cover of its March 2013 issue.
16. *Small* highlighted our joint work with B. Liu on the lipid-PEG-folate encapsulated nanoparticles with AIE characteristics for fluorescent cellular imaging (**2012**, *8*, 3655) as the front cover of issue 23 on 7 Dec 2012.
17. The paper published by Prof. W.-Y Wong in *Adv. Mater.* **2012**, 24, 1034 was highlighted as the Frontispiece cover, while that in *J. Mater. Chem.* **2012**, 22, 7136 was highlighted as the back front cover.
18. The paper published by Prof. K. S. Wong in *J. Phys. Chem. C* **2012**, 116, 9259 was selected for the Top Cover of the April 26, 2012 issue of *J. Phys. Chem. C*.
19. JACS$^{\beta}$ highlighted the joint work of Prof. B. Z. Tang with Prof. B. Liu in National University of Singapore on Specific Detection of Integrin αvβ3 by AIE Bioprobe as JACS Image Challenge #210 on 12 Sept 2012.
20. Russell Johnson published his interview of Prof. B. Z. Tang in the Author Profile column of Journal of Materials Chemistry Blog on 22 Aug 2012.
21. Making our World Safer: Genesis highlighted the work of Prof. B. Z. Tang on development of fluorescent chemosensor for explosives detection on 10 Aug 2012.
22. Phys.Org highlighted the joint work of Prof. B. Z. Tang with Prof. B. Liu in National University of Singapore on development of AIE fluorogens that provide new probes for cancer diagnosis and therapy on 18 July 2012.
23. Erica Mills highlighted the joint work of Prof. B. Z. Tang with Prof. J. u in Jilin University on supersensitive detection of explosives by recyclable AIE luminogen-functionalized mesoporous materials (*Chem. Commun.* **2012**, *48*, 7167) as a news item (Lighting the way to explosive detection) in Chemistry World published by RSC on 12 June 2012.
24. Russell Johnson highlighted the work of Prof. B. Z. Tang on synthesis and self-assembly of AIE-active triazoles (*J. Mater. Chem.* **2012**, 22, 10472–10479) in the Journal of Materials Chemistry Blog as a one of This Week's Hot Papers on 6 June 2012.
25. Journal of Materials Chemistry highlighted the self-assembly structures of AIE luminogens synthesized by Prof. B. Z. Tang (**2012**, 22, 10472) as the front cover of issue 21 on 7 June 2012.
26. The article published by research group of Prof. B. Z. Tang "Efficient Solid Emitters with Aggregation-Induced Emission and Intramolecular Charge Transfer Characteristics: Molecular Design, Synthesis, Photophysical Behaviors, and OLED Application" was in the list of the Most Read papers from Chemistry of Materials between April and June 2012.
27. The work published by Prof. B. Z. Tang on the development of fluorescent explosive sensors was highlighted by Xiaoyun Yang in Asian Scientists on 26 April 2012.
28. Russell Johnson highlighted work of Prof. B. Z. Tang in the Polymer Chemistry Blog on the development of fluorescent chemosensor for explosives detection (*Polym. Chem.* **2012**, *3*, 1481) on 16 April 2012.
29. Rachel Blakeburn highlighted the work of Prof. B. Z. Tang in the Chemical Science Blog on an AIE-active hemicyanine fluorogen with stimuli-responsive red/blue emission (*Chem. Sci.* **2012**, *3*, 1804) on 20 March 2012.

30. Julien Nicolas highlighted the work of Prof. B. Z. Tang in the column of Polymer Chemistry Author of the Week on the metal-free click polymerization of propiolates and azides (Polymer Chemistry **2012**, *3*, 1075) on 2 March 2012.
31. The paper published by prof. B. Z. Tang "Metal-Free Click Polymerization of Propiolates and Azides: Facile Synthesis of Functional Poly(aroxycarbonyltriazole)s" was amongst the top ten accessed articles published in Polymer Chemistry in Feb 2012.
32. Advanced Functional Materials highlighted the joint work of Prof. B. Z. Tang with Prof. B. Liu in National University on the development of biocompatible AIE nanoparticles as NIR fluorescent bioprobes for in vivo imaging applications (**2012**, 22, 771) as the front cover of issue 4 on 22 Feb 2012.
33. Russell Johnson highlighted the work of Prof. B. Z. Tang on the construction of soft porous crystal with silole luminogens as a "Hot Paper" in a commentary entitled "Yellow to Red: A soft porous crystal with mechanofluorochromism on the JMC Blog on 7 Nov 2011.
34. Timothy M. Swager and Olesya Haze highlighted the work of Prof. B. Z. Tang on the development of a polymerization reaction in a commentary entitled "Conjugated Polymers via Aroyl Chloride–Alkyne Polymerization" in SynFacts published by Thieme Stuttgart (SynFacts **2011**, 11, 1190).
35. Gary A. Baker highlighted the work of Prof. B. Z. Tang on the detection of protease and antitrypsin by fluorogenic protein assembly in Noteworthy Chemistry published by ACS on June 6, 2011.
36. Timothy M. Swager and Jason R. Cox highlighted the work of Prof. B. Z. Tang on thiol-yen click polymerization in a commentary entitled "Click it!" in SynFacts published by Thieme Stuttgart (SynFacts **2011**, 7, 385).
37. The work of Prof. B. Z. Tang on metal-free click polymerization has been highlighted by Medical News Today (1 May 2011), Physics News (2 May 2011), Asian Scientist (2 May 2011), Red Orbit (2 May 2011), and Science News World (4 July 2011).