AFRL-AFOSR-VA-TR-2022-0677

Peptide-DNA tiles as building blocks for complex nanostructures

Stephanopoulos, Nicholas
ARIZONA STATE UNIVERSITY
660 S MILL AVE STE 312
TEMPE, AZ, 85281
USA

09/26/2022
Final Technical Report

Air Force Research Laboratory
Air Force Office of Scientific Research
Arlington, Virginia 22203
Air Force Materiel Command

REPORT DOCUMENTATION PAGE

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION.

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED	
20220926	Final	START DATE 20161201	END DATE 20191130

4. TITLE AND SUBTITLE
Peptide-DNA tiles as building blocks for complex nanostructures

5a. CONTRACT NUMBER	5b. GRANT NUMBER	5c. PROGRAM ELEMENT NUMBER
	FA9550-17-1-0053	61102F
5d. PROJECT NUMBER	**5e. TASK NUMBER**	**5f. WORK UNIT NUMBER**

6. AUTHOR(S)
Nicholas Stephanopoulos

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
ARIZONA STATE UNIVERSITY
660 S MILL AVE STE 312
TEMPE, AZ 85281
USA

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)	11. SPONSOR/MONITOR'S REPORT NUMBER(S)
Air Force Office of Scientific Research 875 N. Randolph St. Room 3112 Arlington, VA 22203	AFRL/AFOSR RTB2	AFRL-AFOSR-VA-TR-2022-0677

12. DISTRIBUTION/AVAILABILITY STATEMENT
A Distribution Unlimited: PB Public Release

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The construction of complex, functional materials that rival the complexity of natural systems is a longstanding goal in nanotechnology. To date, DNA has proved to be one of the most flexible and programmable materials for building complex assemblies. However, DNA nanomaterials are restricted to the physical and chemical properties of the oligonucleotides that comprise them, and are generally limited in their functionality. We propose to develop a novel category of peptide-DNA hybrids in order to merge the chemical and functional diversity of peptides/proteins with the structural complexity of DNA. We will synthesize three new categories of peptide-DNA "tiles", based on (1) coiled-coil peptide interactions, (2) collagen triple helices, and (3) trimerizing
protein subunits. These tiles will be used to construct two-dimensional lattices and three-dimensional polyhedral cages with enhanced stability and chemical diversity. We will also incorporate photo switchable azobenzene linkers to enable reversible switching of peptide-DNA nanostructures using light. Finally, we will create a novel category of DNA-peptide-DNA triblock molecules, which will enable us to mask the external surfaces of DNA nanostructures with peptide loops. This peptide surface will increase the surface functionality of DNA and further enhance its stability after covalent crosslinking. Taken together, the work in this proposal will create a new hybrid field of peptide-DNA nanotechnology and enable nanomachines and devices for biosensors, reversible protein control, and nucleation of optoelectronic components on a peptide-DNA scaffold. As such, it will greatly expand the capabilities, stabilities, and performance of DNA-based constructs, and find broad applications in many disciplines of interest to both basic science and military importance.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES
a. REPORT	b. ABSTRACT	c. THIS PAGE		
U	U	U	UU	2

19a. NAME OF RESPONSIBLE PERSON	19b. PHONE NUMBER *(Include area code)*
BENNETT IBEY	000-0000

From: Air Force Office of Scientific Research
To: Technical Reports
Subject: [URL Verdict: Neutral][Non-DoD Source] Deliverable Received: FA9550-17-1-0053
Date: Saturday, April 9, 2022 4:45:55 PM

OMA Team,
A new Final Performance has been submitted for your attention. Award Number: FA9550-17-1-0053

Supporting Report: https://afosr.gov1.qualtrics.com/WRQualtricsSurveyEngine/File.php?F=F_3r205Wf1vNQkvjQ

- Date Stamp: 16:43:23 , 4/9/2022
- Title: Peptide-DNA Tiles as Building Blocks for the Synthesis of Complex Nanostructures
- DISTRIBUTION: Yes- Approved for Public Release (Distro A)
- Principal Investigator: Nicholas Stephanopoulos
  - PI Email: nstepha1@asu.edu
- Program Officer: Patrick Bradshaw
- Report Type: Final Performance
- Reporting Period
  - Start Date: 12/01/2016
  - End Date: 11/30/2019
- Award Number: FA9550-17-1-0053
- Report Due Date: 02/29/2020

ABSTRACT:
The construction of complex, functional materials that rival the complexity of natural systems is a longstanding goal in nanotechnology. To date, DNA has proved to be one of the most flexible and programmable materials for building complex assemblies. However, DNA nanomaterials are restricted to the physical and chemical properties of the oligonucleotides that comprise them, and are generally limited in their functionality. We propose to develop a novel category of peptide-DNA hybrids in order to merge the chemical and functional diversity of peptides/proteins with the structural complexity of DNA. We will synthesize three new categories of peptide-DNA “tiles”, based on (1) coiled-coil peptide interactions, (2) collagen triple helices, and (3) trimerizing protein subunits. These tiles will be used to construct two-dimensional lattices and three-dimensional polyhedral cages with enhanced stability and chemical diversity. We will also incorporate photoswitchable azobenzene linkers to enable reversible switching of peptide-DNA nanostructures using light. Finally, we will create a novel category of DNA-peptide-DNA triblock molecules, which will enable us to mask the external surfaces of DNA nanostructures with peptide loops. This peptide surface will increase the surface functionality of DNA and further enhance its stability after covalent crosslinking. Taken together, the work in this proposal will create a new hybrid field of

peptide-DNA nanotechnology and enable nanomachines and devices for biosensors, reversible protein control, and nucleation of optoelectronic components on a peptide-DNA scaffold. As such, it will greatly expand the capabilities, stabilities, and performance of DNA-based constructs, and find broad applications in many disciplines of interest to both basic science and military importance.