CONFIDENTIAL DISCLOSURE AND RECORD OF INVENTION (**ROI**) FORM

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ALL QUESTIONS MUST BE ANSWERED

1. ***Title***

Biosensors Derived from the Incorporation of Viruses into poly(3,4-ethylenedioxythiophenes) (PEDOT) Nanowires

2. ***General Subject Matter:***

Conducting polymer nanowires and films were synthesized with M13 bacteriophage incorporated by electropolymerization

3. ***Names of persons connected with the work. For UC collaborators, list employment status (e.g. faculty, postdoc, graduate student) and date of employment at UC (mm/dd/yyyy):***

In the event that a patent application is filed by the University, actual inventorship will be determined as a matter of law by a patent attorney.

Name (Only the first person listed will be the 'lead'*)	**UC Employment Status**	**Date of Employment at UC**
Gregory A. Weiss	Faculty	
Reginald M. Penner	Faculty	
Jessica A. Arter	Graduate Student	08/07
David K. Taggart	Graduate Student	08/05
Theresa M. McIntire		

*** The 'lead' is OTA's point of contact for issues regarding the invention.**

4. **a)** ***Brief description of the invention:***

What is it? How is it done? What is the purpose? What is the fundamental principle?

Using lithographically patterned nanowire electrodeposition, PEDOT nanowires and films are electropolymerized at the surface of an electrode. Inclusion of M13 bacteriophage in the growth solution allows for incorporation of the phage into the PEDOT polymer. After etching, isolated PEDOT nanowires and films with phage incorporated remain. The fundamental principle for synthesis is the use of phage as a large, negatively-charged particle for incorporation of arbitrary phage-displayed proteins into an electrically conducting polymer. These phage nanowires/films can be used for real-time electrical resistance biosensing and electron transfer directly to proteins and other biological molecules.

b) The invention is a new: **---X--Product** **---X--Process**

-----Composition **-----Method of use**

(check all applicable)

5. ***Funding source(s):***

List the funding source(s) for the project under which this invention was made. If applicable, identify by contract or grant number and name the Principal Investigator / Supervisor of each.

Funding Source / Sponsor	**Contract or Grant Number**	**Principal Investigator / Supervisor**

6. ***Proprietary materials:***

If any proprietary material (e.g., cell line, antibody, plasmid, computer software, or chemical compound) obtained from outside your laboratory was used to develop this invention, please check the box below or attach a copy of that agreement. None

This invention utilized Data or Materials from:

-----A subscription to the proprietary database Celera

-----Affymetrix Chips

-----Material Transfer Agreement (MTA)

-----Other proprietary material (Please Explain)

(check all applicable)

7. ***Relevant Dates:***

Item	**Conception and First Written Description**	**First Successful Operation**
Date	12.16.09	1.15.10
By whom	Jessica A. Arter	Jessica A. Arter
Where Recorded	Arter notebook 3 pg. 84	Arter notebook 3 pg. 97
To Whom First Disclosed	Gregory A. Weiss, Reginald M. Penner, David K. Taggart, Keith Donavan, Rosa Pilolli	Gregory A. Weiss, Reginald M. Penner, David K. Taggart, Keith Donavan, Rosa Pilolli
Date First Disclosed	12.16.09	1.18.10

8. **Disclosures:**

If you have disclosed this invention to non-UC personnel (including research sponsor) then indicate when, under what circumstances, and to whom.

a. **orally** In part, at Cambridge Healthtech Inaugural Future Diagnostics Conference.

b. **in writing** In part, by an abstract for CHI conference.

c. **by actual use, demonstration, or posters** In part, at a poster presentation at CHI conference.

9. ***Publication:***

Has this subject matter been published or disclosed anywhere in the form of a report (including sponsor), abstract, paper, thesis, or conference presentation? If so, where and when? Do you plan to submit a manuscript, and if so, has a manuscript been prepared? If yes, give details, including the actual or planned date of submission. If a manuscript has been accepted, give the anticipated publication date. Append a copy of the latest draft manuscript available. (See instructions for the effect of publication prior to the filing of a patent application.)

A manuscript is currently being drafted. We would like to submit in a month.

10. ***Prior Art:***

State all known prior art, published or unpublished, including related UC Irvine work, which bears on the invention. In the case of chemical compounds, present closely related structures? How does the invention differ from the prior art? Has a literature or patent search of this matter been made by you or for you? If so, attach copies of the most pertinent references. If none, state why not?

Asplund M.; von Holst H.; Inganäs O. *Biointerphases* **2008**, *3*, 83-93.

Xiao, Y.H.; Li, C.M.; Toh, M.-L.; Xue, R. *J. Appl. Electrochem*. **2008**, *38*, 1735-1741.

Two pertinent references are stated above. These references show DNA incorporated into PEDOT, while being polymerized on gold, and heparin and hyaluronic acid incorporated into PEDOT, and isolated as films. The biggest difference in the prior art versus this invention is that we are using bacteriophage (viruses), they are 16 MDa large molecules, which is much larger than the 3-30 kDa heparin. The synthesis also allows for isolated nanowires of PEDOT, rather than films.

-----No Known Prior Art **-----No Prior Art Search Done**

11. ***Problem Solved:***

How was the problem solved in the past? What was the disadvantage to overcome?

Sensing of biomolecules is often done in an ELISA format, in electrochemical assays with bacteriophage or by many other less efficient strategies. The molecular recognition elements are covalently linked to the electrode surface. However, the linking chemistry is not always reliable, and surface functionalization processes can be time consuming.

12. ***Advantages:***

State the advantages which the invention has over the prior ways of achieving the same purpose.

The reported synthesis offers an inexpensive, more rapid and robust functionalization of electrodes with a potentially lower limit of detection, and reagent-free biosensing.

13. ***Detailed Examples and/or Drawings:***

Attach flow sheets of syntheses showing the contemplated scope, and detailed examples of how the invention is made and operates. Include drawings, graphs, figures, etc. to support inventive process. When available, include physical constants.

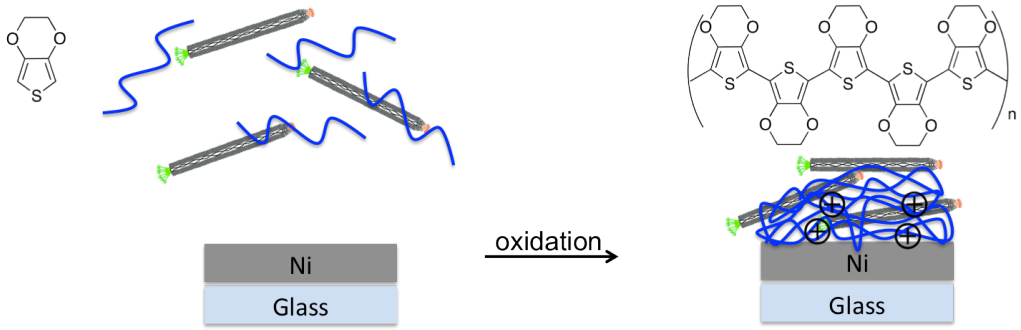


Figure 1. Foundation for the idea: phage bear a net-negative protein coat, and act as a counter anion for EDOT polymerization.

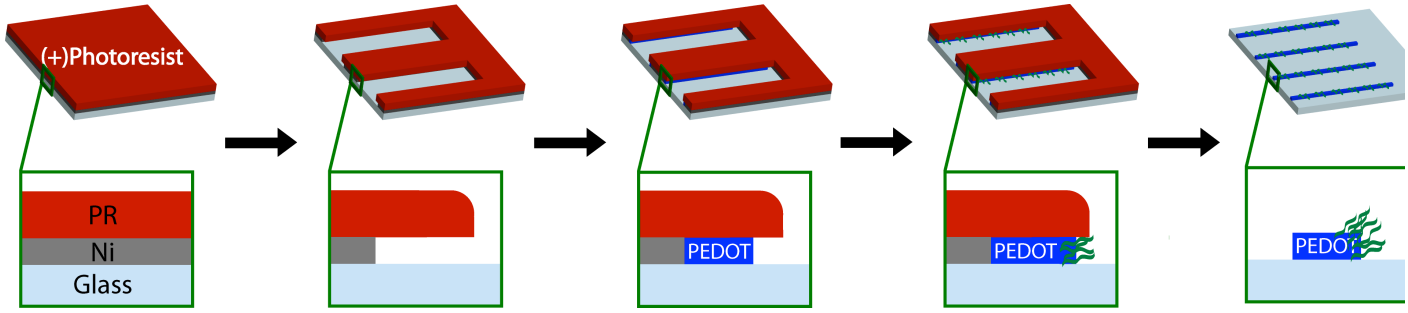


Figure 2. Lithographically-patterned nanowire electrodeposition (LPNE) is the technique used for synthesis of the isolated PEDOT-phage nanowires.

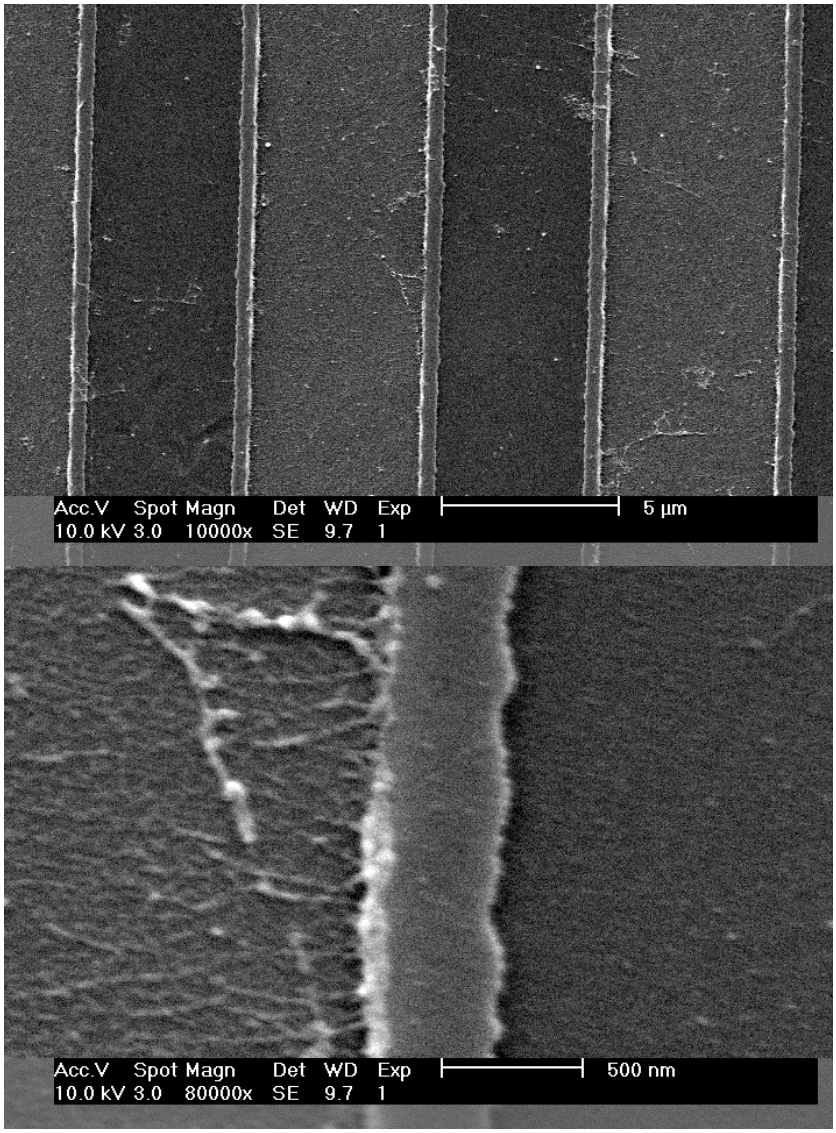


Figure 3. Scanning electron microscope images of PEDOT-phage nanowires, where string-like particles can be seen attached to the nanowires, with the dimensions of small bundles of phage.

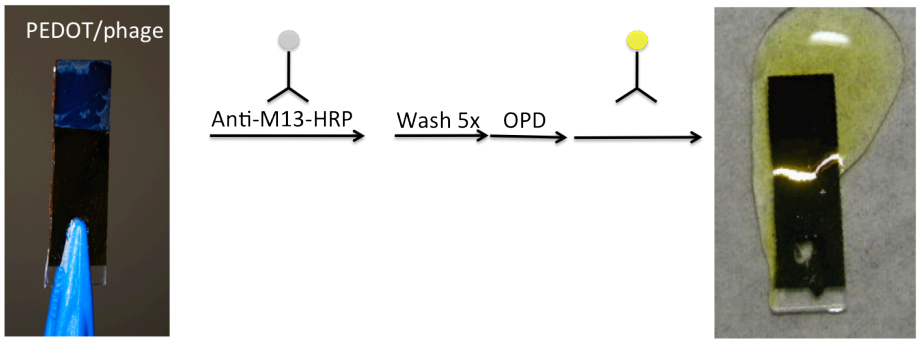
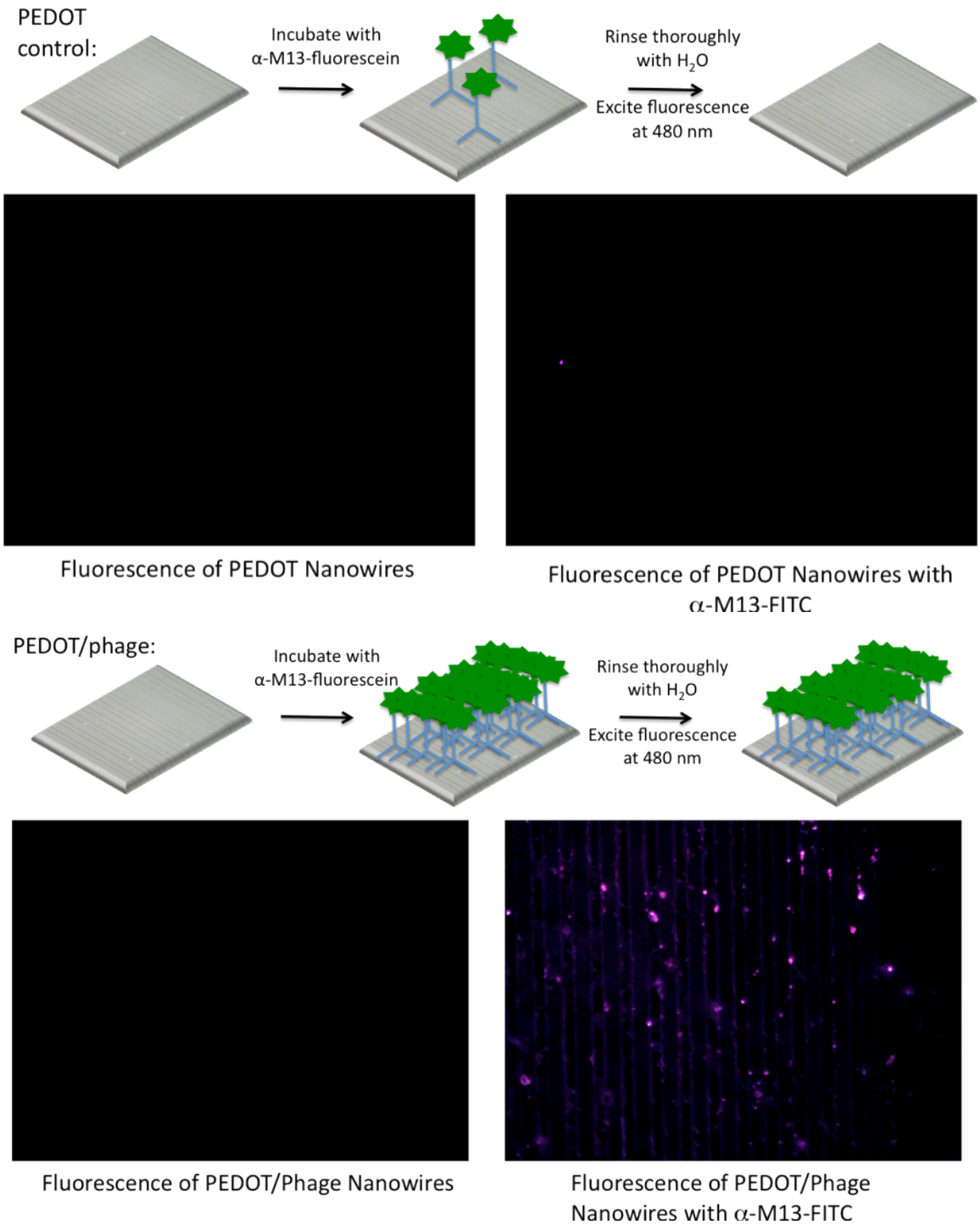


Figure 4. Enzyme-linked immuno-sorbent assay (ELISA) on PEDOT-phage turns over a yellow color upon incubation with an anti-M13antibody conjugated to horse radish peroxidase (HRP), followed by *o*-phenylenediamine.



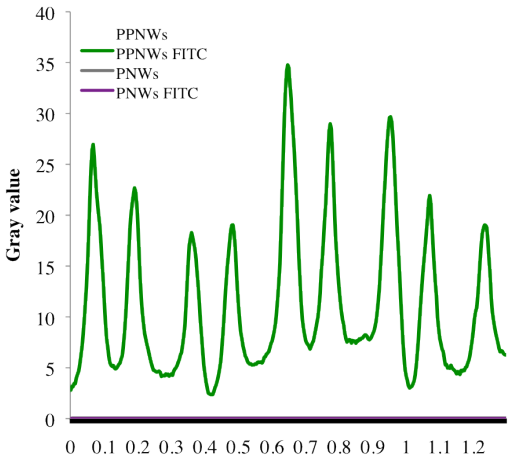


Figure 5. Fluorescence assays with anti-M13 conjugated to fluorescein used as a fluorophore. Data shows no fluorescence at the PEDOT nanowires, and increased fluorescence localized to the PEDOT-phage nanowires, indicating binding of the fluorescent antibody. Analysis of the data by Image J shows increased pixel intensity localized to the nanowires(right).

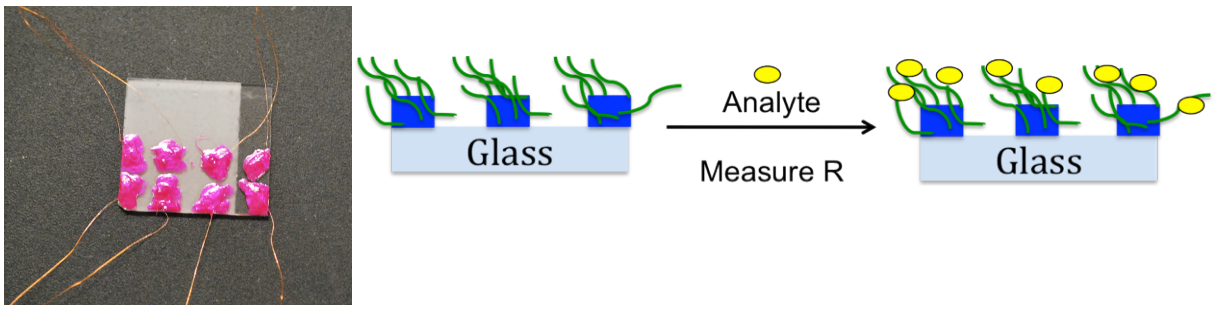


Figure 6. Optical image of the device, where arrays of PEDOT-phage nanowires are between the pink contacts (left). A schematic of the phage incorporated into the PEDOT nanowires, where analyte interactions are observed in real-time by electrochemical measurements.

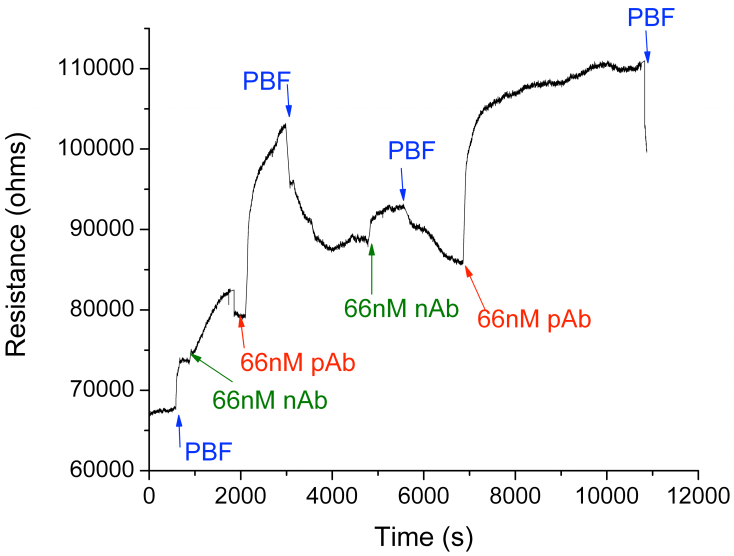


Figure 7. Real-time, reagent-free resistance measurements using the PEDOT-phage nanowire array device. Green arrows indicate measurements with anti-flag antibody, red arrows indicate measurements with anti-M13 antibody, and blue arrows indicate rinsing with buffer.

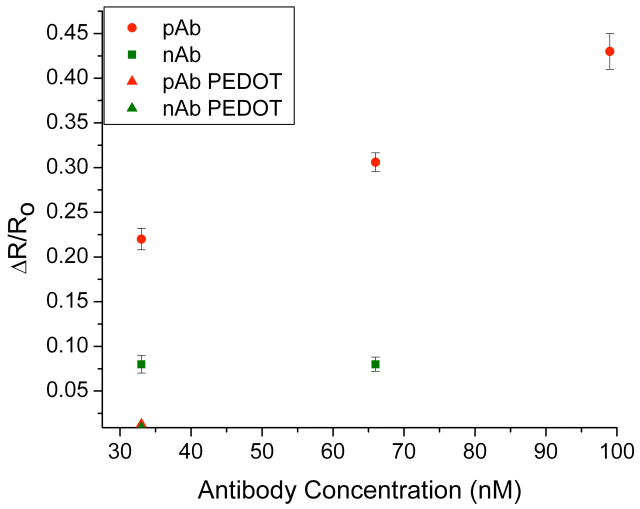


Figure 8. A compilation of the change in resistance measurements over the initial resistance ($\Delta R/R_o$) for measurements taken with each of the various analytes. A linear correlation of increasing resistance is observed for anti-M13 antibody. The triangle data points were taken as a control with no phage incorporated into the PEDOT nanowires.

14. ***Regulatory Approval:***

Were any human or animal subjects used to obtain data to support this disclosure? If yes, did you get all necessary regulatory approvals?

No.

15. ***Utility:***

What are the proposed uses for the invention? Give a detailed description of how to use it (dosages, formulations, therapeutic treatment of a disease, etc. as appropriate).

We foresee at least two major applications made possible by our approach. First, the system offers real-time, reagent-free early detection of biomarkers. Various recognition ligands can be attached to the phage coat, and upon incorporation of the phage into the PEDOT nanowires/film, changes in electrical resistance can indicate binding to analytes. In addition, the phage can display redox active enzymes driven by direct electrical current.

16. ***Commercial Use:***

Has this invention had any public or commercial use? If so, what? Where? When? If public or commercial use is expected in the immediate future, indicate what, where, and when. Include date of first order or sale, if applicable.

No.

17. ***Potential Licensees or Research & Development Sponsors:***

List companies you believe might be interested in using, developing or marketing this invention. Would you be interested in collaborating with the potential licensee? ---X--Yes -----No

Molecular Express, Inc.

18. ***Signatures, Names and addresses of persons mentioned in Question 3:***

Signature / Date	**Signature / Date**
Print Name Gregory A. Weiss	**Print Name** Reginald M. Penner
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Note: If there are more persons please provide signatures, names and addresses on an additional sheet of paper.

Signatures, Names and addresses of persons mentioned in Question 3:

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Campus Extension (UC Collaborators only) X2514	**Campus Extension (UC Collaborators only)**
Email jarter@uci.edu	**Email** taggartd@uci.edu

19. ***Non-UC Collaborator(s):***
For any person named above in #18, who is not employed full-time by the University of California, please identify other employers (e.g., Veterans Administration, Howard Hughes Medical Institute, USDA), the percent of salary time funded by such other employer, and the nature of the other employment (such as research, teaching or clinical duties)

19. ***Technically Qualified Witnesses (Two Required)----invention disclosed to and understood by:***

Signature / Date	**Signature / Date**
Print Name	**Print Name**

Submit this form with ORIGINAL SIGNATURES directly to:

Kevin Kennan
Assistant Director, Intellectual Property Administration
Office of Technology Alliances
380 University Tower
4199 Campus Drive
Irvine, CA. 92697-7700

If you do not receive an acknowledgment within 30 days, please call the above at (949) 824-4608.

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Effective 1/1/82 **Retention: 7 years after last patent expires or 10 years after the date of the last action whichever is later**