

**Table ST1.** COIN characteristics and assay performance before and after purification.

Detection Method	Signal/Background <i>Mean ± Std. Dev.; p-value</i>		Spot-to-Spot Variation <i>Mean ± Std. Dev.; p-value</i>		Accuracy <sup>1</sup> <i>Mean ± Std. Dev.; p-value</i>	
	PSA-COIN, unpurified	11 ± 6	<i>p=0.35</i>	92 ± 25	<i>p=0.15</i>	0.91 ± 0.02
PSA-COIN, FPLC purified	11 ± 3	77 ± 2		0.93 ± 0.04		
PSA-Alexa (direct conjugate)	6 ± 2	<i>p=0.01</i> <sup>3</sup>	38 ± 6	<i>p=0.32</i>	0.98 ± 0.01	<i>p=0.74</i>
PSA-COIN + Alexa (secondary) <sup>2</sup>	12 ± 6		49 ± 8		0.97 ± 0.01	

<sup>1</sup> fraction of correctly classified spots in the epithelium and stroma, *i.e.*, (true positive pixels + true negative pixels)/total pixels.

<sup>2</sup> The COIN stain was applied first followed by the Alexa secondary, which targeted the primary antibody conjugated to COIN.

<sup>3</sup> the intensity of secondary staining is expected to be greater than that of the direct conjugate due to an amplification effect.